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RESOLUTION A.800(19)
adopted on 23 November 1995

REVISED GUIDELINES FOR APPROVAL OF SPRINKLER SYSTEMS EQUIVALENT TO THAT REFERRED TO IN SOLAS REGULATION II-2/12

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

NOTING the significance of the performance and reliability of the sprinkler systems approved under the provisions of regulation II-2/12 of the International Convention for the Safety of Life at Sea (SOLAS), 1974,

DESIROUS of keeping abreast of the advancement of sprinkler technology and further improving fire protection on board ships,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its sixty-fourth session,

1. ADOPTS the Revised Guidelines for Approval of Sprinkler Systems Equivalent to that referred to in SOLAS regulation II-2/12 set out in the Annex to the present resolution;

2. INVITES Governments to apply the Guidelines when approving equivalent sprinkler systems;

3. REQUESTS the Maritime Safety Committee to keep the Guidelines under review and to amend them as necessary;

4. REVOKES resolution A.755(18).

ANNEX

REVISED GUIDELINES FOR APPROVAL OF SPRINKLER SYSTEMS EQUIVALENT TO THAT REFERRED TO IN SOLAS REGULATION II-2/12

1 General

Equivalent sprinkler systems must have the same characteristics which have been identified as significant to the performance and reliability of automatic sprinkler systems approved under the requirements of SOLAS regulation II-2/12.

2 Definitions

2.1 **Antifreeze system**: A wet pipe sprinkler system employing automatic sprinklers attached to a piping system containing an antifreeze solution and connected to a water supply. The antifreeze solution is discharged, followed by water, immediately upon operation of sprinklers opened by heat from a fire.

2.2 **Deluge system**: A sprinkler system employing open sprinklers attached to a piping system connected to a water supply through a valve that is opened by the operation of a detection system installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system and discharges from all sprinklers attached thereto.

2.3 **Dry pipe system**: A sprinkler system employing automatic sprinklers attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve. The water then flows into the piping system and out of the opened sprinklers.

2.4 **Preaction system**: A sprinkler system employing automatic sprinklers attached to a piping system containing air that may or may not be under pressure, with a supplemental detection system installed in the same area as the sprinklers. Actuation of the detection system opens a valve that permits water to flow into the sprinkler piping system and to be discharged from any sprinklers that may be open.

2.5 **Water-based extinguishing medium**: Fresh water or sea water with or without additives mixed to enhance fire-extinguishing capability.

2.6 **Wet pipe system**: A sprinkler system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by heat from a fire.

3 Principal requirements for the system

3.1 The system should be automatic in operation, with no human action necessary to set it in operation.

3.2 The system should be capable of both detecting the fire and acting to control or suppress the fire with a water-based extinguishing medium.

3.3 The sprinkler system should be capable of continuously supplying the water-based extinguishing medium for a minimum of 30 min. A pressure tank should be provided to meet the functional requirement stipulated in SOLAS regulation II-2/12.4.1.

3.4 The system should be of the wet pipe type but small exposed sections may be of the dry pipe, preaction, deluge, antifreeze or other type to the satisfaction of the Administration where this is necessary.

3.5 The system should be capable of fire control or suppression under a wide variety of fire loading, fuel arrangement, room geometry and ventilation conditions.

3.6 The system and equipment should be suitably designed to withstand ambient temperature changes, vibration, humidity, shock, impact, clogging and corrosion normally encountered in ships.

3.7 The system and its components should be designed and installed in accordance with international standards acceptable to the Organization[*], and manufactured and tested to the satisfaction of the Administration in accordance with the requirements given in appendices 1 and 2 to these guidelines.

3.8 The system should be provided with both main and emergency sources of power.

3.9 The system should be provided with a redundant means of pumping or otherwise supplying a water-based extinguishing medium to the sprinkler system.

3.10 The system should be fitted with a permanent sea inlet and be capable of continuous operation using seawater.

3.11 The piping system should be sized in accordance with an hydraulic calculation technique.[**]

3.12 Sprinklers should be grouped into separate sections. Any section should not serve more than two decks of one main vertical zone.

3.13 Each section of sprinklers should be capable of being isolated by one stop valve only. The stop valve in each section should be readily accessible and its location should be clearly and permanently indicated. Means should be provided for preventing the stop valves being operated by an unauthorized person.

[*]Pending the development of international standards acceptable to the Organization, national standards as prescribed by the Administration should be applied.

[**]Where the Hazen-Williams Method is used, the following values of the friction factor "C" for different pipe types which may be considered should apply:

Pipe type	C
Black or galvanized mild steel	120
Copper and copper alloys	150
Stainless steel	150
Plastic	150

3.14 Sprinkler piping should not be used for any other purpose.

3.15 The sprinkler system supply components should be outside category A machinery spaces.

3.16 A means for testing the automatic operation of the system for assuring the required pressure and flow should be provided.

3.17 Each sprinkler section should be provided with a means for giving a visual and audible alarm at a continuously manned central control station within one minute of flow from one or more sprinklers, a check valve, pressure gauge, and a test connection with a means of drainage.

3.18 A sprinkler control plan should be displayed at each centrally manned control station.

3.19 Installation plans and operating manuals should be supplied to the ship and be readily available on board. A list or plan should be displayed showing the spaces covered and the location of the zone in respect of each section. Instructions for testing and maintenance should also be available on board.

3.20 Sprinklers should have fast response characteristics as defined in ISO standard 6182-1.

3.21 In accommodation and service spaces the sprinklers should have a nominal temperature rating of 57°C to 79°C, except that in locations such as drying rooms, where high ambient temperatures might be expected, the nominal temperature may be increased by not more than 30°C above the maximum deckhead temperature.

3.22 Pumps and alternative supply components should be sized so as to be capable of maintaining the required flow to the hydraulically most demanding area of not less than 280 m^2. For application to a small ship with a total protected area of less than 280 m^2, the Administration may specify the appropriate area for sizing of pumps and alternative supply components.

APPENDIX 1

COMPONENT MANUFACTURING STANDARDS FOR WATER MIST NOZZLES

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1 INTRODUCTION

1.1 This document is intended to address minimum fire protection performance, construction and marking requirements, excluding fire performance, for water mist nozzles.

1.2 Numbers in brackets following a section or subsection heading refer to the appropriate section or paragraph in the standard for automatic sprinkler systems (part 1: Requirements and methods of test for sprinklers, ISO 6182-1).

2 DEFINITIONS

2.1 Conductivity factor (C): a measure of the conductance between the nozzle's heat responsive element and the fitting expressed in units of $(m/s)^{0.5}$.

2.2 Rated working pressure: maximum service pressure at which a hydraulic device is intended to operate.

2.3 Response time index (RTI): a measure of nozzle sensitivity expressed as $RTI = tu^{0.5}$, where **t** is the time constant of the heat responsive element in units of seconds, and **u** is the gas velocity expressed in metres per second. RTI can be used in combination with the conductivity factor (C) to predict the response of a nozzle in fire environments defined in terms of gas temperature and velocity versus time. RTI has units of $(m \cdot s)^{0.5}$.

2.4 Standard orientation: in the case of nozzles with symmetrical heat responsive elements supported by frame arms, standard orientation is with the air flow perpendicular to both the axis of the nozzle's inlet and the plane of the frame arms. In the case of non-symmetrical heat responsive elements, standard orientation is with the air flow perpendicular to both the inlet axis and the plane of the frame arms which produces the shortest response time.

2.5 Worst case orientation: the orientation which produces the longest response time with the axis of the nozzle inlet perpendicular to the air flow.

3 PRODUCT CONSISTENCY

3.1 It should be the responsibility of the manufacturer to implement a quality control programme to ensure that production continuously meets the requirements in the same manner as the originally tested samples.

3.2 The load on the heat responsive element in automatic nozzles should be set and secured by the manufacturer in such a manner so as to prevent field adjustment or replacement.

4 WATER MIST NOZZLE REQUIREMENTS

4.1 Dimensions

Nozzles should be provided with a nominal 6 mm (1/4 in.) or larger nominal inlet thread or equivalent. The dimensions of all threaded connections should conform to international standards where applied. National standards may be used if international standards are not applicable.

4.2 Nominal release temperatures [6.2]*

*Figures given in square brackets refer to ISO standard 6182-1.

4.2.1 The nominal release temperatures of automatic glass bulb nozzles should be as indicated in table 1.

4.2.2 The nominal release temperatures of fusible automatic element nozzles should be specified in advance by the manufacturer and verified in accordance with 4.3. Nominal release temperatures should be within the ranges specified in table 1.

4.2.3 The nominal release temperature that is to be marked on the nozzle should be that determined when the nozzle is tested in accordance with 5.6.1, taking into account the specifications of 4.3.

Table 1 - Nominal release temperature

GLASS BULB NOZZLES		FUSIBLE ELEMENT NOZZLES	
Nominal release temperature (ºC)	Liquid color code	Nominal release temperature (ºC)	Frame color code +
57	orange	57 to 77	uncolored
68	red	80 to 107	white
79	yellow	121 to 149	blue
93-100	green	163 to 191	red
121-141	blue	204 to 246	green
163-182	mauve	260 to 343	orange
204-343	black		

+ - Not required for decorative nozzles.

4.3 Operating temperatures (see 5.6.1) [6.3]

Automatic nozzles should open within a temperature range of

$$X \pm (0.035X + 0.62)°C$$

where X is the nominal release temperature.

4.4 Water flow and distribution

4.4.1 Flow constant (see 5.10) [6.4.1]

4.4.1.1 The flow constant K for nozzles is given by the formula:

$$K = \frac{Q}{P^{0.5}}$$

where:

P is the pressure in bars;
Q is the flow rate in litres per minute.

4.4.1.2 The value of the flow constant K published in the manufacturer's design and installation instructions should be verified using the test method of 5.10. The average flow constant K should be within ±5% of the manufacturer's value.

4.4.2 Water distribution (see 5.11)

Nozzles which have complied with the requirements of the fire test should be used to determine the effective nozzle discharge characteristics when tested in accordance with 5.11.1. These characteristics should be published in the manufacturer's design and installation instructions.

4.4.3 Water droplet size and velocity (see 5.11.2)

The water droplet size distribution and droplet velocity distribution should be determined in accordance with 5.11.2 for each design nozzle at the minimum and maximum operating pressures, and minimum and maximum air flow rates, when used, as part of the identification of the discharge characteristics of the nozzles which have demonstrated compliance with the fire test. The measurements should be made at two representative locations:

.1 perpendicular to the central axis of the nozzle, exactly 1 m below the discharge orifice or discharge deflector; and

.2 radially outward from the first location at either 0.5 m or 1 m distance, depending on the distribution pattern.

4.5 Function (see 5.5) [6.5]

4.5.1 When tested in accordance with 5.5, the nozzle should open and, within 5 s after the release of the heat responsive element, should operate satisfactorily by complying with the requirements of 5.10. Any lodgement of released parts should be cleared within 60 s of release for standard response heat responsive elements and within 10 s of release for fast and special response heat responsive elements or the nozzle should then comply with the requirements of 5.11.

4.5.2 The nozzle discharge components should not sustain significant damage as a result of the functional test specified in 5.5 and should have the same flow constant range and water droplet size and velocity within 5% of values as previously determined in accordance with 4.4.1 and 4.4.3.

4.6 Strength of body (see 5.3) [6.6]

The nozzle body should not show permanent elongation of more than 0.2% between the load-bearing points after being subjected to twice the average service load as determined using the method of 5.3.1.

4.7 Strength of release element [6.7]

4.7.1 Glass bulbs (see 5.9.1)

The lower tolerance limit for bulb strength should be greater than two times the upper tolerance limit for the bulb design load based on calculations with a degree of confidence of 0.99 for 99% of the samples as determined in 5.9.1. Calculations will be based on the normal or gaussian distribution except where another distribution can be shown to be more applicable due to manufacturing or design factors.

4.7.2 Fusible elements (see 5.9.2)

Fusible heat-responsive elements in the ordinary temperature range should be designed to:

.1 sustain a load of 15 times its design load corresponding to the maximum service load measured in 5.3.1 for a period of 100 h; or

.2 demonstrate the ability to sustain the design load.

4.8 Leak resistance and hydrostatic strength (see 5.4) [6.8]

4.8.1 A nozzle should not show any sign of leakage when tested by the method specified in 5.4.1.

4.8.2 A nozzle should not rupture, operate or release any parts when tested by the method specified in 5.4.2.

4.9 Heat exposure [6.9]

4.9.1 Glass bulb nozzles (see 5.7.1)

There should be no damage to the glass bulb element when the nozzle is tested by the method specified in 5.7.1.

4.9.2 All uncoated nozzles (see 5.7.2)

Nozzles should withstand exposure to increased ambient temperature without evidence of weakness or failure, when tested by the method specified in 5.7.2.

4.9.3 Coated nozzles (see 5.7.3)

In addition to meeting the requirement of 5.7.2 in an uncoated version, coated nozzles should withstand exposure to ambient temperatures without evidence of weakness or failure of the coating, when tested by the method specified in 5.7.3.

4.10 Thermal shock (see 5.8) [6.10]

Glass bulb nozzles should not be damaged when tested by the method specified in 5.8. Proper operation is not considered as damage.

4.11 Corrosion [6.11]

4.11.1 Stress corrosion (see 5.12.1 and 5.12.2)

When tested in accordance with 5.12.1, all brass nozzles should show no fractures which could affect their ability to function as intended and satisfy other requirements.

When tested in accordance with 5.12.2, stainless steel parts of water mist nozzles should show no fractures or breakage which could affect their ability to function as intended and satisfy other requirements.

4.11.2 Sulphur dioxide corrosion (see 5.12.3)

Nozzles should be sufficiently resistant to sulphur dioxide saturated with water vapour when conditioned in accordance with 5.12.3. Following exposure, five nozzles should operate when functionally tested at their minimum flowing pressure (see 4.5.1 and 4.5.2). The remaining five samples should meet the dynamic heating requirements of 4.14.2.

4.11.3 Salt spray corrosion (see 5.12.4)

Coated and uncoated nozzles should be resistant to salt spray when conditioned in accordance with 5.12.4. Following exposure, the samples should meet the dynamic heating requirements of 4.14.2.

4.11.4 Moist air exposure (see 5.12.5)

Nozzles should be sufficiently resistant to moist air exposure and should satisfy the requirements of 4.14.2 after being tested in accordance with 5.12.5.

4.12 Integrity of nozzle coatings [6.12]

4.12.1 Evaporation of wax and bitumen used for atmospheric protection of nozzles (see 5.13.1)

Waxes and bitumens used for coating nozzles should not contain volatile matters in sufficient quantities to cause shrinkage, hardening, cracking or flaking of the applied coating. The loss in mass should not exceed 5% of that of the original sample when tested by the method in 5.13.1.

4.12.2 Resistance to low temperatures (see 5.13.2)

All coatings used for nozzles should not crack or flake when subjected to low temperatures by the method in 5.13.2.

4.12.3 Resistance to high temperature (see 4.9.3)

Coated nozzles should meet the requirements of 4.9.3.

4.13 Water hammer (see 5.15) [6.13]

Nozzles should not leak when subjected to pressure surges from 4 bar to four times the rated pressure for operating pressures up to 100 bars and two times the rated pressure for pressures greater than 100 bar. They should show no signs of mechanical damage when tested in accordance with 5.15 and should operate within the parameters of 4.5.1 at the minimum design pressure.

4.14 Dynamic heating (see 5.6.2) [6.14]

4.14.1 Automatic nozzles intended for installation in other than accommodation spaces and residential areas should comply with the requirements for RTI and C limits shown in figure 1. Automatic nozzles intended for installation in accommodation spaces or residential areas should comply with fast response requirements for RTI and C limits shown in figure 1. Maximum and minimum RTI values for all data points calculated using C for the fast and standard response nozzles should fall within the appropriate category shown in figure 1. Special response nozzles should have an average RTI value, calculated using C, between 50 and 80 with no value less than 40 or more than 100. When tested at an angular offset to the worst case orientation as described in 5.6.2, the RTI should not exceed 600 $(m.s)^{0.5}$ or 250% of the value of RTI in the standard orientation, whichever is the less. The angular offset should be 15° for standard response, 20° for special response and 25° for fast response.

4.14.2 After exposure to the corrosion test described in 4.11.2, 4.11.3 and 4.11.4, nozzles should be tested in the standard orientation as described in 5.6.2.1 to determine the post exposure RTI. All post exposure RTI values should not exceed the limits shown in figure 1 for the appropriate category. In addition, the average RTI value should not exceed 130% of the pre-exposure average value. All post exposure RTI values should be calculated as in 5.6.2.3 using the pre-exposure conductivity factor (C).

4.15 Resistance to heat (see 5.14) [6.15]

Open nozzles should be sufficiently resistant to high temperatures when tested in accordance with 5.14. After exposure, the nozzle should not show:

.1 visual breakage or deformation;

.2 a change in flow constant K of more than 5%; and

.3 no changes in the discharge characteristics of the water distribution test (see 4.4.2) exceeding 5%.

4.16 Resistance to vibration (see 5.16) [6.16]

Nozzles should be able to withstand the effects of vibration without deterioration of their performance characteristics when tested in accordance with 5.16. After the vibration test of 5.16, nozzles should show no visible deterioration and should meet the requirements of 4.5 and 4.8.

4.17 Impact test (see 5.17) [6.17]

Nozzles should have adequate strength to withstand impacts associated with handling, transport and installation without deterioration of their performance or reliability. Resistance to impact should be determined in accordance with 5.17.

4.18 Lateral discharge (see 5.18) [6.19]

Nozzles should not prevent the operation of adjacent automatic nozzles when tested in accordance with 5.18.

4.19 30-day leakage resistance (see 5.19) [6.20]

Nozzles should not leak, sustain distortion or other mechanical damage when subjected to twice the rated pressure for 30 days. Following exposure, the nozzles should satisfy the test requirements of 5.4.

4.20 Vacuum resistance (see 5.20) [6.21]

Nozzles should not exhibit distortion, mechanical damage or leakage after being subjected to the test specified in 5.20.

4.21 Water shield [6.22 and 6.23]

4.21.1 General

An automatic nozzle intended for use at intermediate levels or beneath open grating should be provided with a water shield which complies with 4.21.2 and 4.21.3.

4.21.2 Angle of protection

Water shields should provide an "angle of protection" of 45° or less for the heat responsive element against direct impingement of run-off water from the shield caused by discharge from nozzles at higher elevations.

4.21.3 Rotation (see 5.21.2)

Rotation of the water shield should not alter the nozzle service load.

4.22 Clogging (see 5.21) [6.28.3]

A water mist nozzle should show no evidence of clogging during 30 min of continuous flow at rated working pressure using water that has been contaminated in accordance with 5.21.3. Following the 30 min of flow, the water flow at rated pressure of the nozzle and strainer or filter should be within ± 10% of the value obtained prior to conducting the clogging test.

5 METHODS OF TEST [7]

5.1 General

The following tests should be conducted for each type of nozzle. Before testing, precise drawings of parts and the assembly should be submitted together with the appropriate specifications (using SI units). Tests should be carried out at an ambient temperature of (20 ± 5)°C, unless other temperatures are indicated.

5.2 Visual examination [7.2]

Before testing, nozzles should be examined visually with respect to the following points:

.1 marking;

.2 conformity of the nozzles with the manufacturer's drawings and specification; and

.3 obvious defects.

5.3 Body strength test [7.3]

5.3.1 The design load should be measured on ten automatic nozzles by securely installing each nozzle, at room temperature, in a tensile/compression test machine and applying a force equivalent to the application of the rated working pressure.

An indicator capable of reading deflection to an accuracy of 0.01 mm should be used to measure any change in length of the nozzle between its load bearing points. Movement of the nozzle shank thread in the threaded bushing of the test machine should be avoided or taken into account.

The hydraulic pressure and load is then released and the heat responsive element is then removed by a suitable method. When the nozzle is at room temperature, a second measurement should be made using the indicator.

An increasing mechanical load to the nozzle is then applied at a rate not exceeding 500 N/min, until the indicator reading at the load bearing point initially measured returns to the initial value achieved under hydrostatic load. The mechanical load necessary to achieve this should be recorded as the service load. Calculation of the average service load should be made.

5.3.2 The applied load should then be progressively increased at a rate not exceeding 500 N/min on each of the five specimens until twice the average service load has been applied. This load should be maintained for 15 ± 5 s.

The load should then be removed and any permanent elongation as defined in 4.6 should be recorded.

5.4 Leak resistance and hydrostatic strength tests (see 4.8) [7.4]

5.4.1 Twenty nozzles should be subjected to a water pressure of twice their rated working pressure, but not less than 34.5 bar. The pressure should be increased from 0 bar to the test pressure, maintained at twice rated working pressure for a period of 3 min and then decreased to 0 bar. After the pressure has returned to 0 bar, it should be increased to the minimum operating pressure specified by the manufacturer in not more than 5 s. This pressure should be maintained for 15 s and then increased to rated working pressure and maintained for 15 s.

5.4.2 Following the test of 5.4.1, the twenty nozzles should be subjected to an internal hydrostatic pressure of four times the rated working pressure. The pressure should be increased from 0 bar to four times the rated working pressure and held there for a period of 1 min. The nozzle under test should not rupture, operate or release any of its operating parts during the pressure increase nor while being maintained at four times the rated working pressure for 1 min.

5.5 Functional test (see 4.5) [7.5]

5.5.1 Nozzles having nominal release temperatures less than 78°C, should be heated to activation in an oven. While being heated, they should be subjected to each of the water pressures specified in 5.5.2 applied to their inlet. The temperature of the oven should be increased to 400 ± 20°C in 3 min measured in close proximity to the nozzle. Nozzles having nominal release temperatures exceeding 78°C should be heated using a suitable heat source. Heating should continue until the nozzle has activated.

5.5.2 Eight nozzles should be tested in each normal mounting position and at pressures equivalent to the minimum operating pressure, the rated working pressure and at the average operating pressure. The flowing pressure should be at least 75% of the initial operating pressure.

5.5.3 If lodgement occurs in the release mechanism at any operating pressure and mounting position, 24 more nozzles should be tested in that mounting position and at that pressure. The total number of nozzles for which lodgement occurs should not exceed 1 in the 32 tested at that pressure and mounting position.

5.5.4 Lodgement is considered to have occurred when one or more of the released parts lodge in the discharge assembly in such a way as to cause the water distribution to be altered after the period of time specified in 4.5.1.

5.5.5 In order to check the strength of the deflector/orifice assembly, three nozzles should be submitted to the functional test in each normal mounting position at 125% of the rated working pressure. The water should be allowed to flow at 125% of the rated working pressure for a period of 15 min.

5.6 Heat responsive element operating characteristics

5.6.1 Operating temperature test (see 4.3) [7.6]

Ten nozzles should be heated from room temperature to 20ºC to 22°C below their nominal release temperature. The rate of increase of temperature should not exceed 20°C/min and the temperature should be maintained for 10 min. The temperature should then be increased at a rate between 0.4°C/min to 0.7°C/min until the nozzle operates.

The nominal operating temperature should be ascertained with equipment having an accuracy of ±0.35% of the nominal temperature rating or ±0.25°C, whichever is greater.

The test should be conducted in a water bath for nozzles or separate glass bulbs having nominal release temperatures less than or equal to 80°C. A suitable oil should be used for higher-rated release elements. The liquid bath should be constructed in such a way that the temperature deviation within the test zone does not exceed 0.5% or 0.5°C, whichever is greater.

5.6.2 Dynamic heating tests (see 4.14)

5.6.2.1 Plunge test

Tests should be conducted to determine the standard and worst case orientations as defined in 2.4 and 2.5. Ten additional plunge tests should be performed at both of the identified orientations. The worst case orientation should be as defined in 4.14.1. The RTI should be calculated as described in 5.6.2.3 and 5.6.2.4 for each orientation, respectively. The plunge tests should be conducted using a brass nozzle mount designed such that the mount or water temperature rise does not exceed 2°C for the duration of an individual plunge test up to a response time of 55 s. (The temperature should be measured by a thermocouple heatsinked and embedded in the mount not more than 8 mm radially outward from the root diameter of the internal thread or by a thermocouple located in the water at the centre of the nozzle inlet.) If the response time is greater than 55 s, then the mount or water temperature in degrees Celsius should not increase more than 0.036 times the response time in seconds for the duration of an individual plunge test.

The nozzle under test should have 1 to 1.5 wraps of PTFE sealant tape applied to the nozzle threads. It should be screwed into a mount to a torque of 15 ± 3 Nm. Each nozzle should be mounted on a tunnel test section cover and maintained in a conditioning chamber to allow the nozzle and cover to reach ambient temperature for a period of not less than 30 min.

At least 25 ml of water, conditioned to ambient temperature, should be introduced into the nozzle inlet prior to testing. A timer accurate to ±0.01 s with suitable measuring devices to sense the time between when the nozzle is plunged into the tunnel and the time it operates should be utilized to obtain the response time.

A tunnel should be utilized with air flow and temperature conditions[*] at the test section (nozzle location) selected from the appropriate range of conditions shown in table 2. To minimize radiation exchange between the sensing element and the boundaries confining the flow, the test section of the apparatus should be designed to limit radiation effects to within ± 3% of calculated RTI values[**].

The range of permissible tunnel operating conditions is shown in table 2. The selected operating condition should be maintained for the duration of the test with the tolerances as specified by footnotes 1 and 2 in table 2.

5.6.2.2 Determination of conductivity factor (C) [7.6.2.2]

The conductivity factor (C) should be determined using the prolonged plunge test (see 5.6.2.2.1) or the prolonged exposure ramp test (see 5.6.2.2.2).

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[*] Tunnel conditions should be selected to limit maximum anticipated equipment error to 3%.

[**] A suggested method for determining radiation effects is by conducting comparative plunge tests on a blackened (high emissivity) metallic test specimen and a polished (low emissivity) metallic test specimen.

5.6.2.2.1 Prolonged plunge test [7.6.2.2.1]

The prolonged plunge test is an iterative process to determine C and may require up to twenty nozzle samples. A new nozzle sample must be used for each test in this section even if the sample does not operate during the prolonged plunge test.

The nozzle under test should have 1 to 1.5 wraps of PTFE sealant tape applied to the nozzle threads. It should be screwed into a mount to a torque of 15 ± 3 Nm. Each nozzle should be mounted on a tunnel test section cover and maintained in a conditioning chamber to allow the nozzle and cover to reach ambient temperature for a period of not less than 30 min. At least 25 ml of water, conditioned to ambient temperature, should be introduced into the nozzle inlet prior to testing.

A timer accurate to ± 0.01 s with suitable measuring devices to sense the time between when the nozzle is plunged into the tunnel and the time it operates should be utilized to obtain the response time.

The mount temperature should be maintained at 20 ± 0.5°C for the duration of each test. The air velocity in the tunnel test section at the nozzle location should be maintained with ± 2% of the selected velocity. Air temperature should be selected and maintained during the test as specified in table 3.

The range of permissible tunnel operating conditions is shown in table 3. The selected operating condition should be maintained for the duration of the test with the tolerances as specified in table 3.

To determine C, the nozzle should be immersed in the test stream at various air velocities for a maximum of 15 min.*** Velocities should be chosen such that actuation is bracketed between two successive test velocities. That is, two velocities should be established such that at the lower velocity (u_l) actuation does not occur in the 15 min test interval. At the next higher velocity (u_h), actuation should occur within the 15-minute time limit. If the nozzle does not operate at the highest velocity, an air temperature from table 3 for the next higher temperature rating should be selected.

***If the value of C is determined to be less than 0.5 $(m \cdot s)^{0.5}$, a C of 0.25 $(m \cdot s)^{0.5}$ should be assumed for calculating RTI value.

TABLE 2 - PLUNGE OVEN TEST CONDITIONS

	Air temperature ranges[1]			**Velocity ranges**[2]		
Normal temperature, ºC	Standard response, ºC	Special response, ºC	Fast response, ºC	Standard response, m/s	Special response, m/s	Fast response nozzle, m/s
57 to 77	191 to 203	129 to 141	129 to 141	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
79 to 107	282 to 300	191 to 203	191 to 203	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
121 to 149	382 to 432	282 to 300	282 to 300	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
163 to 191	382 to 432	382 to 432	382 to 432	3.4 to 3.6	2.4 to 2.6	1.65 to 1.85

[1]The selected air temperature should be known and maintained constant within the test section throughout the test to an accuracy of ± 1°C for the air temperature range of 129ºC to 141°C within the test section and within ± 2°C for all other air temperatures.

[2]The selected air velocity should be known and maintained constant throughout the test to an accuracy of ± 0.03 m/s for velocities of 1.65 to 1.85 and 2.4 m/s to 2.6 m/s and ± 0.04 m/s for velocities of 3.4 m/s to 3.6 m/s.

TABLE 3 - PLUNGE OVEN TEST CONDITIONS FOR CONDUCTIVITY DETERMINATIONS

Nominal nozzle temperature, ºC	Oven temperature, ºC	Maximum variation of air temperature during test, ºC
57	85 to 91	± 1.0
58 to 77	124 to 130	± 1.5
78 to 107	193 to 201	± 3.0
121 to 149	287 to 295	± 4.5
163 to 191	402 to 412	± 6.0

Test velocity selection should ensure that:

$(U_H/U_L)^{0.5} \leq 1.1$

The test value of C is the average of the values calculated at the two velocities using the following equation:

$C = (\_\ Tg/\_\ Tea - 1)u^{0.5}$

where:

_ Tg = Actual gas (air) temperature minus the mount temperature (Tm) in °C;

_ Tea = Mean liquid bath operating temperature minus the mount temperature (Tm) in °C;

u = Actual air velocity in the test section in m/s.

The nozzle C value is determined by repeating the bracketing procedure three times and calculating the numerical average of the three C values. This nozzle C value is used to calculate all standard orientation RTI values for determining compliance with 4.14.1.

5.6.2.2.2 Prolonged exposure ramp test [7.6.2.2.2]

The prolonged exposure ramp test for the determination of the parameter C should be carried out in the test section of a wind tunnel and with the requirements for the temperature in the nozzle mount as described for the dynamic heating test. A preconditioning of the nozzle is not necessary.

Ten samples should be tested of each nozzle type, all nozzles positioned in standard orientation. The nozzle should be plunged into an air stream of a constant velocity of 1 m/s ± 10% and an air temperature at the nominal temperature of the nozzle at the beginning of the test.

The air temperature should then be increased at a rate of 1 ± 0.25°C/min until the nozzle operates. The air temperature, velocity and mount temperature should be controlled from the initiation of the rate of rise and should be measured and recorded at nozzle operation. The C value is determined using the same equation as in 5.6.2.2.1 as the average of the ten test values.

5.6.2.3 RTI value calculation [7.6.2.3]

The equation used to determine the RTI value is as follows:

$$RTI = \frac{-t_r (u)^{0.5} (1 + C/(u)^{0.5})}{\ln [1 - \Delta T_{ea} (1 + C/(u)^{0.5})/\Delta T_g]}$$

where:

t_r = Response time of nozzles in seconds;

u = Actual air velocity in the test section of the tunnel in m/s from table 2;

$\_T_{ea}$ = Mean liquid bath operating temperature of the nozzle minus the ambient temperature in °C;

$\_T_g$ = Actual air temperature in the test section minus the ambient temperature in °C;

C = Conductivity factor as determined in 5.6.2.2.

5.6.2.4 Determination of worst case orientation RTI

The equation used to determine the RTI for the worst case orientation is as follows:

$$RTI_{wc} = \frac{-t_{r-wc} (u)^{0.5} [1 + C(RTI_{wc}/RTI)/(u)^{0.5}]}{\ln\{1 - \Delta T_{ea} [1 + C(RTI_{wc}/RTI)/(u)^{0.5}]/\Delta T_g\}}$$

where:

t_{r-wc} = Response time of the nozzles in seconds for the worst case orientation.

All variables are known at this time as per the equation in 5.6.2.3 except RTI_{wc} (response time index for the worst case orientation) which can be solved iteratively as per the above equation.
In the case of fast response nozzles, if a solution for the worse case orientation RTI is unattainable, plunge testing in the worst case orientation should be repeated using the plunge test conditions under Special Response shown in table 2.

5.7 Heat exposure tests [7.7]

5.7.1 Glass bulb nozzles (see 4.9.1)

Glass bulb nozzles having nominal release temperatures less than or equal to 80ºC should be heated in a water bath from a temperature of 20 ± 5ºC to 20 ± 2ºC below their nominal release temperature. The rate of increase of temperature should not exceed 20ºC/min. High temperature oil, such as silicone oil should be used for higher temperature rated release elements.

This temperature should then be increased at a rate of 1°C/min to the temperature at which the gas bubble dissolves, or to a temperature 5°C lower than the nominal operating temperature, whichever is lower. The nozzle should be removed from the liquid bath and allowed to cool in air until the gas bubble has formed again. During the cooling period, the pointed end of the glass bulb (seal end) should be pointing downwards. This test should be performed four times on each of four nozzles.

5.7.2 All uncoated nozzles (see 4.9.2) [7.7.2]

Twelve uncoated nozzles should be exposed for a period of 90 days to a high ambient temperature that is 11°C below the nominal rating or at the temperature shown in table 4, whichever is lower, but not less than 49ºC. If the service load is dependent on the service pressure, nozzles should be tested under the rated working pressure. After exposure, four of the nozzles should be subjected to the tests specified in 5.4.1, four nozzles to the test of 5.5.1, two at the minimum operating pressure and two at the rated working pressure, and four nozzles to the requirements of 4.3. If a nozzle fails the applicable requirements of a test, eight additional nozzles should be tested as described above and subjected to the test in which the failure was recorded. All eight nozzles should comply with the test requirements.

5.7.3 Coated nozzles (see 4.9.3) [7.7.3]

In addition to the exposure test of 5.7.2 in an uncoated version, 12 coated nozzles should be exposed to the test of 5.7.2 using the temperatures shown in table 4 for coated nozzles.

The test should be conducted for 90 days. During this period, the sample should be removed from the oven at intervals of approximately 7 days and allowed to cool for 2 h to 4 h. During this cooling period, the sample should be examined. After exposure, four of the nozzles should be subjected to the tests specified in 5.4.1, four nozzles to the test of 5.5.1; two at the minimum operating pressure and two at the rated working pressure, and four nozzles to the requirements of 4.3.

TABLE 4 - TEST TEMPERATURES FOR COATED AND UNCOATED NOZZLES

Values in ºC		
Nominal release temperature	Uncoated nozzle test temperature	Coated nozzle test temperature
57-60	49	49
61-77	52	49
78-107	79	66
108-149	121	107
150-191	149	149
192-246	191	191
247-302	246	246
303-343	302	302

5.8 Thermal shock test for glass bulb nozzles (see 4.10) [7.8]

Before starting the test, at least 24 nozzles at room temperature of 20ºC to 25ºC for at least 30 min should be conditioned.

The nozzles should be immersed in a bath of liquid, the temperature of which should be 10 ± 2ºC below the nominal release temperature of the nozzles. After 5 min, the nozzles should be removed from the bath and immersed immediately in another bath of liquid, with the bulb seal downwards, at a temperature of 10 ± 1ºC. Then the nozzles should be tested in accordance with 5.5.1.

5.9 Strength tests for release elements [7.9]

5.9.1 Glass bulbs (see 4.7.1) [7.9.1]

At least 15 samples bulbs in the lowest temperature rating of each bulb type should be positioned individually in a test fixture using the sprinkler seating parts. Each bulb should then be subjected to a uniformly increasing force at a rate not exceeding 250 N/s in the test machine until the bulb fails.

Each test should be conducted with the bulb mounted in new seating parts. The mounting device may be reinforced externally to prevent its collapse, but in a manner which does not interfere with bulb failure.

The failure load for each bulb should be recorded. Calculation of the lower tolerance limit (TL1) for bulb strength should be made. Using the values of service load recorded in 5.3.1, the upper tolerance limit (TL2) for the bulb design load should be made. Compliance with 4.7.1 should be verified.

5.9.2 Fusible elements (see 4.7.2)

5.10 Water flow test (see 4.4.1) [7.10]

The nozzle and a pressure gauge should be mounted on a supply pipe. The water flow should be measured at pressures ranging from the minimum operating pressure to the rated working pressure at intervals of approximately 10% of the service pressure range on two sample nozzles. In one series of tests, the pressure should be increased from zero to each value and, in the next series, the pressure should be decreased from the rated pressure to each value. The flow constant K should be averaged from each series of readings, i.e., increasing pressure and decreasing pressure. During the test, pressures should be corrected for differences in height between the gauge and the outlet orifice of the nozzle.

5.11 Water distribution and droplet size tests

5.11.1 Water distribution (see 4.4.2)

The tests should be conducted in a test chamber of minimum dimensions 7 m x 7 m or 300% of the maximum design area being tested, whichever is greater. For standard automatic nozzles, a single open nozzle should be installed and then four open nozzles of the same type arranged in a square, at maximum spacings specified by the manufacturer, on piping prepared for this purpose. For pilot type nozzles, a single nozzle should be installed and then the maximum number of slave nozzles at their maximum spacings, specified in the manufacturer's design and installation instructions.

The distance between the ceiling and the distribution plate should be 50 mm for upright nozzles and 275 mm for pendent nozzles. For nozzles without distribution plates, the distances should be measured from the ceiling to the highest nozzle outlet.

Recessed, flush and concealed type nozzles should be mounted in a false ceiling of dimensions not less than 6 m x 6 m and arranged symmetrically in the test chamber. The nozzles should be fitted directly into the horizontal pipework by means of "T" or elbow fittings.

The water discharge distribution in the protected area below a single nozzle and between the multiple nozzles should be collected and measured by means of square measuring containers nominally 300 mm on a side. The distance between the nozzles and the upper edge of the measuring containers should be the maximum specified by the manufacturer. The measuring containers should be positioned centrally, beneath the single nozzle and beneath the multiple nozzles.

The nozzles should be discharged both at the minimum operating and rated working pressures specified by the manufacturer and the minimum and maximum installation heights specified by the manufacturer.

The water should be collected for at least 10 min to assist in characterizing nozzle performance.

5.11.2 Water droplet size (see 4.4.3)

The mean water droplet diameters, velocities, droplet size distribution, number density and volume flux should be determined at both the minimum and maximum flow rates specified by the manufacturer. Once the data is gathered, the method of the "Standard practice for determining data criteria and processing for liquid drop size analysis" (ASTM E799-92) will be used to determine the appropriate sample size, class size widths, characteristic drop sizes and measured dispersion of the drop size distribution. This data should be taken at various points within the spray distribution as described in 4.4.3.

5.12 Corrosion tests [7.12]

5.12.1 Stress corrosion test for brass nozzle parts (see 4.11.1)

Five nozzles should be subjected to the following aqueous ammonia test. The inlet of each nozzle should be sealed with a non-reactive cap, e.g. plastic.

The samples should be degreased and exposed for 10 days to a moist ammonia-air mixture in a glass container of volume 0.02 ± 0.01 m³.

An aqueous ammonia solution, having a density of 0.94 g/cm³, should be maintained in the bottom of the container, approximately 40 mm below the bottom of the samples. A volume of aqueous ammonia solution corresponding to 0.01 ml per cubic centimeter of the volume of the container will give approximately the following atmospheric concentrations: 35% ammonia, 5% water vapour, and 60% air. The inlet of each sample should be sealed with a non-reactive cap, e.g. plastic.

The moist ammonia-air mixture should be maintained as closely as possible at atmospheric pressure, with the temperature maintained at 34 ± 2°C. Provision should be made for venting the chamber via a capillary tube to avoid the build-up of pressure. Specimens should be shielded from condensate drippage.

After exposure, the nozzles should be rinsed and dried, and a detailed examination should be conducted. If a crack, delamination or failure of any operating part is observed, the nozzle(s) should be subjected to a leak resistance test at the rated pressure for 1 min and to the functional test at the minimum flowing pressure (see 4.5.1).

Nozzles showing cracking, delamination or failure of any non-operating part should not show evidence of separation of permanently attached parts when subjected to flowing water at the rated working pressure for 30 min.

5.12.2 Stress-Corrosion Cracking of Stainless Steel Nozzle Parts (see 4.11.1)

5.12.2.1 Five samples are to be degreased prior to being exposed to the magnesium chloride solution.

5.12.2.2 Parts used in nozzles should be placed in a 500-millilitre flask that is fitted with a thermometer and a wet condenser approximately 760 mm long. The flask should be filled approximately one-half full with a 42% by weight magnesium chloride solution, placed on a thermostatically-controlled electrically heated mantel, and maintained at a boiling temperature of 150±1°C. The parts should be unassembled, that is, not contained in a nozzle assembly. The exposure should last for 500 h.

5.12.2.3 After the exposure period, the test samples should be removed from the boiling magnesium chloride solution and rinsed in deionized water.

5.12.2.4 The test samples should then be examined using a microscope having a magnification of 25X for any cracking, delamination, or other degradation as a result of the test exposure. Test samples exhibiting degradation should be tested as described in 5.12.2.5 or 5.12.2.6, as applicable. Test samples not exhibiting degradation are considered acceptable without further test.

5.12.2.5 Operating parts exhibiting degradation should be further tested as follows. Five new sets of parts should be assembled in nozzle frames made of materials that do not alter the corrosive effects of the magnesium chloride solution on the stainless steel parts. These test samples should be degreased and subjected to the magnesium chloride solution exposure specified in 5.12.2.2. Following the exposure, the test samples should withstand, without leakage, a hydrostatic test pressure equal to the rated working pressure for 1 min and then be subjected to the functional test at the minimum operating pressure in accordance with 5.5.1.

5.12.2.6 Non-operating parts exhibiting degradation should be further tested as follows. Five new sets of parts should be assembled in nozzle frames made of materials that do not alter the corrosive effects of the magnesium chloride solution on the stainless steel parts. These test samples should be degreased and subjected to the magnesium chloride solution exposure specified in paragraph 5.12.4.1. Following the exposure, the test samples should withstand a flowing pressure equal to the rated working pressure for 30 min without separation of permanently attached parts.

5.12.3 Sulphur dioxide corrosion test (see 4.11.2 and 4.14.2)

Ten nozzles should be subjected to the following sulphur dioxide corrosion test. The inlet of each sample should be sealed with a non-reactive cap, e.g. plastic.

The test equipment should consist of a 5-litre vessel (instead of a 5-litre vessel, other volumes up to 15 litres may be used in which case the quantities of chemicals given below should be increased in proportion) made of heat-resistant glass, with a corrosion-resistant lid of such a shape as to prevent condensate dripping on the nozzles. The vessel should be electrically heated through the base and provided with a cooling coil around the side walls. A temperature sensor placed centrally 160 ± 20 mm above the bottom of the vessel should regulate the heating so that the temperature inside the glass vessel is 45 ± 3°C. During the test, water should flow through the cooling coil at a sufficient rate to keep the temperature of the discharge water below 30°C. This combination of heating and cooling should encourage condensation on the surfaces of the nozzles. The sample nozzles should be shielded from condensate drippage.

The nozzles to be tested should be suspended in their normal mounting position under the lid inside the vessel and subjected to a corrosive sulphur dioxide atmosphere for 8 days. The corrosive atmosphere should be obtained by introducing a solution made up by dissolving 20 g of sodium thiosulfate ($Na_2S_2O_3H_2O$) crystals in 500 ml of water.

For at least six days of the 8-day exposure period, 20 ml of dilute sulphuric acid consisting of 156 ml of normal H_2SO_4 (0.5 mol/l) diluted with 844 ml of water should be added at a constant rate. After 8 days, the nozzles should be removed from the container and allowed to dry for 4 to 7 days at a temperature not exceeding 35°C with a relative humidity not greater than 70%.

After the drying period, five nozzles should be subjected to a functional test at the minimum operating pressure in accordance with 5.5.1 and five nozzles should be subjected to the dynamic heating test in accordance with 4.14.2.

5.12.4 Salt spray corrosion test (see 4.11.3 and 4.14.2) [7.12.3]

5.12.4.1 Nozzles intended for normal atmospheres

Ten nozzles should be exposed to a salt spray within a fog chamber. The inlet of each sample should be sealed with a non-reactive cap, e.g. plastic.

During the corrosive exposure, the inlet thread orifice should be sealed by a plastic cap after the nozzles have been filled with deionized water. The salt solution should be a 20% by mass sodium chloride solution in distilled water. The pH should be between 6.5 and 3.2 and the density between 1.126 g/ml and 1.157 g/ml when atomized at 35°C. Suitable means of controlling the atmosphere in the chamber should be provided. The specimens should be supported in their normal operating position and exposed to the salt spray (fog) in a chamber having a volume of at least 0.43 m^3 in which the exposure zone should be maintained at a temperature of 35 ± 2°C. The temperature should be recorded at least once per day, at least 7 h apart (except weekends and holidays when the chamber normally would not be opened). Salt solution should be supplied from a recirculating reservoir through air-aspirating nozzles, at a pressure between 0.7 bar (0.07 MPa) and 1.7 bar (0.17 MPa). Salt solution runoff from exposed samples should be collected and should not return to the reservoir for recirculation. The sample nozzles should be shielded from condensate drippage.

Fog should be collected from at least two points in the exposure zone to determine the rate of application and salt concentration. The fog should be such that for each 80 cm^2 of collection area, 1 ml to 2 ml of solution should be collected per hour over a 16-hour period and the salt concentration should be 20 ± 1%

by mass.

The nozzles should withstand exposure to the salt spray for a period of 10 days. After this period, the nozzles should be removed from the fog chamber and allowed to dry for 4 to 7 days at a temperature of 20ºC to 25°C in an atmosphere having a relative humidity not greater than 70%. Following the drying period, five nozzles should be submitted to the functional test at the minimum operating pressure in accordance with 5.5.1 and five nozzles should be subjected to the dynamic heating test in accordance with 4.14.2.

5.12.4.2 Nozzles intended for corrosive atmospheres [7.12.3.2]

Five nozzles should be subjected to the tests specified in 5.12.4.1 except that the duration of the salt spray exposure should be extended from 10 days to 30 days.

5.12.5 Moist air exposure test (see 4.11.4 and 4.14.2) [7.12.4]

Ten nozzles should be exposed to a high temperature-humidity atmosphere consisting of a relative humidity of 98 ± 2% and a temperature of 95 ± 4ºC. The nozzles should be installed on a pipe manifold containing deionized water. The entire manifold should be placed in the high temperature-humidity enclosure for 90 days. After this period, the nozzles should be removed from the temperature-humidity enclosure and allowed to dry for 4 to 7 days at a temperature of 25 ± 5°C in an atmosphere having a relative humidity of not greater than 70%. Following the drying period, five nozzles should be functionally tested at the minimum operating pressure in accordance with 5.5.1 and five nozzles should be subjected to the dynamic heating test in accordance with 4.14.2.*

5.13 Nozzle coating tests [7.13]

5.13.1 Evaporation test (see 4.12.1) [7.13.1]

A 50 cm^3 sample of wax or bitumen should be placed in a metal or glass cylindrical container, having a flat bottom, an internal diameter of 55 mm and an internal height of 35 mm. The container, without lid, should be placed in an automatically controlled electric, constant ambient temperature oven with air circulation. The temperature in the oven should be controlled at 16°C below the nominal release temperature of the nozzle, but at not less than 50°C. The sample should be weighed before and after a 90-day exposure to determine any loss of volatile matter. The sample should meet the requirements of 4.12.1.

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*At the manufacturer's option, additional samples may be furnished for this test to provide early evidence of failure. The additional samples may be removed from the test chamber at 30-day intervals for testing.

5.13.2 Low-temperature test (see 4.12.2) [7.13.2]

Five nozzles, coated by normal production methods, whether with wax, bitumen or a metallic coating, should be subjected to a temperature of -10°C for a period of 24 h. On removal from the low-temperature cabinet, the nozzles should be exposed to normal ambient temperature for at least 30 min before examination of the coating to the requirements of 4.12.2.

5.14 Heat resistance test (see 4.15) [7.14]

One nozzle body should be heated in an oven at 800°C for a period of 15 min, with the nozzle in its normal installed position. The nozzle body should then be removed, holding it by the threaded inlet, and should be promptly immersed in a water bath at a temperature of approximately 15°C. It should meet the requirements of 4.15.

5.15 Water hammer test (see 4.13) [7.15]

Five nozzles should be connected, in their normal operating position, to the test equipment. After purging the air from the nozzles and the test equipment, 3,000 cycles of pressure varying from 4 ± 2 bar (0.4 ± 0.2 MPa) to twice the rated working pressure should be generated. The pressure should be raised from 4 bar to twice the rated pressure at a rate of 60 ± 10 bar/s. At least 30 cycles of pressure per minute should be generated. The pressure should be measured with an electrical pressure transducer.

Each nozzle should be visually examined for leakage during the test. After the test, each nozzle should meet the leakage resistance requirement of 4.8.1 and the functional requirement of 4.5.1 at the minimum operating pressure.

5.16 Vibration test (see 4.16) [7.16]

5.16.1 Five nozzles should be fixed vertically to a vibration table. They should be subjected at room temperature to sinusoidal vibrations. The direction of vibration should be along the axis of the connecting thread.

5.16.2 The nozzles should be vibrated continuously from 5 Hz to 40 Hz at a maximum rate of 5 min/octave and an amplitude of 1 mm (1/2 peak-to-peak value). If one or more resonant points are detected, the nozzles after coming to 40 Hz, should be vibrated at each of these resonant frequencies for 120 h/number of resonances. If no resonances are detected, the vibration from 5 Hz to 40 Hz should be continued for 120 h.

5.16.3 The nozzle should then be subjected to the leakage test in accordance with 4.8.1 and the functional test in accordance with 4.5.1 at the minimum operating pressure.

5.17 Impact test (see 4.17) [7.17]

Five nozzles should be tested by dropping a mass onto the nozzle along the axial centreline of waterway. The kinetic energy of the dropped mass at the point of impact should be equivalent to a mass equal to that of the test nozzle dropped from a height of 1 m (see figure 2). The mass should be prevented from impacting more than once upon each sample.

Following the test, a visual examination of each nozzle should show no signs of fracture, deformation or other deficiency. If none is detected, the nozzles should be subjected to the leak resistance test, described in 5.4.1. Following the leakage test, each sample should meet the functional test requirement of 5.5.1 at a pressure equal to the minimum flowing pressure.

5.18 Lateral discharge test (see 4.18) [7.19]

Water should be discharged from a spray nozzle at the minimum operating and rated working pressure. A second automatic nozzle located at the minimum distance specified by the manufacturer should be mounted on a pipe parallel to the pipe discharging water.

The nozzle orifices or distribution plates (if used) should be placed 550 mm, 356 mm and 152 mm below a flat smooth ceiling for three separate tests, respectively at each test pressure. The top of a square pan measuring 305 mm square and 102 mm deep should be positioned 152 mm below the heat responsive element for each test. The pan should be filled with 0.47 l of heptane. After ignition, the automatic nozzle should operate before the heptane is consumed.

5.19 30-day leakage test (see 4.19) [7.20]

Five nozzles should be installed on a water filled test line maintained under a constant pressure of twice the rated working pressure for 30 days at an ambient temperature of 20 ± 5°C.

The nozzles should be inspected visually at least weekly for leakage. Following completion of this 30-day test, all samples should meet the leak resistance requirements specified in 4.8 and should exhibit no evidence of distortion or other mechanical damage.

5.20 Vacuum test (see 4.20) [7.21]

Three nozzles should be subjected to a vacuum of 460 mm of mercury applied to a nozzle inlet for 1 min at an ambient temperature of 20 ± 5°C. Following this test, each sample should be examined to verify that no distortion or mechanical damage has occurred and then should meet the leak resistance requirements specified in 5.4.1.

5.21 Clogging test (see 4.22) [7.28]

5.21.1 The water flow rate of an open water mist nozzle with its strainer or filter should be measured at its rated working pressure. The nozzle and strainer or filter should then be installed in test apparatus described in figure 3 and subjected to 30 min of continuous flow at rated working pressure using contaminated water which has been prepared in accordance with 5.21.3.

5.21.2 Immediately following the 30 min of continuous flow with the contaminated water, the flow rate of the nozzle and strainer or filter should be measured at rated working pressure. No removal, cleaning or flushing of the nozzle, filter or strainer is permitted during the test.

5.21.3 The water used during the 30 min of continuous flow at rated working pressure specified in 5.21.1 should consist of 60 l of tap water into which has been mixed 1.58 kg of contaminants which sieve as described in table 5. The solution should be continuously agitated during the test.

TABLE 5

CONTAMINANT FOR CONTAMINATED WATER CYCLING TEST

SIEVE DESIGNATION[1]	NOMINAL SIEVE OPENING, MM	GRAMS OF CONTAMINANT (± 5%)[2]		
		PIPE SCALE	TOP SOIL	SAND
No. 25	0.706	-	456	200
No. 50	0.297	82	82	327
No.100	0.150	84	6	89
No.200	0.074	81	-	21
No.325	0.043	153	-	3
	TOTAL	400	544	640

[1]Sieve designations correspond with those specified in the standard for wire-cloth sieves for testing purposes, ASTM E11-87, CENCO-MEINZEN sieve sizes 25 mesh, 50 mesh, 100 mesh, 200 mesh and 325 mesh, corresponding with the number designation in the table, have been found to comply with ASTM E11-87.

[2]The amount of contaminant may be reduced by 50% for nozzles limited to use with copper or stainless steel piping and by 90% for nozzles having a rated pressure of 50 bar or higher and limited to use with stainless steel piping.

6 WATER MIST NOZZLE MARKINGS

6.1 General

Each nozzle complying with the requirements of this standard should be permanently marked as follows:

.1 trademark or manufacturer's name;

.2 model identification;

.3 manufacturer's factory identification. This is only required if the manufacturer has more than one nozzle manufacturing facility;

.4 nominal year of manufacture* (automatic nozzles only);

.5 nominal release temperature** (automatic nozzles only); and

*The year of manufacture may include the last three months of the preceding year and the first six months of the following year. Only the last two digits need be indicated.

**Except for coated and plated nozzles, the nominal release temperature range should be color-coded on the nozzle to identify the nominal rating. The colour code should be visible on the yoke arms holding the distribution plate for fusible element nozzles, and should be indicated by the colour of the liquid in glass bulbs. The nominal temperature rating should be stamped or cast on the fusible element of fusible element nozzles. All nozzles should be stamped, cast, engraved or colour-coded in such a way that the nominal rating is recognizable even if the nozzle has operated. This should be in accordance with table 1.

.6 K-factor. This is only required if a given model nozzle is available with more than 1 orifice size.

In countries where colour-coding of yoke arms of glass bulb nozzles is required, the colour code for fusible element nozzles should be used.

6.2 Nozzle housings

Recessed housings, if provided, should be marked for use with the corresponding nozzles unless the housing is a non-removable part of the nozzle.

FIGURE 1

RTI AND C LIMITS FOR STANDARD ORIENTATION

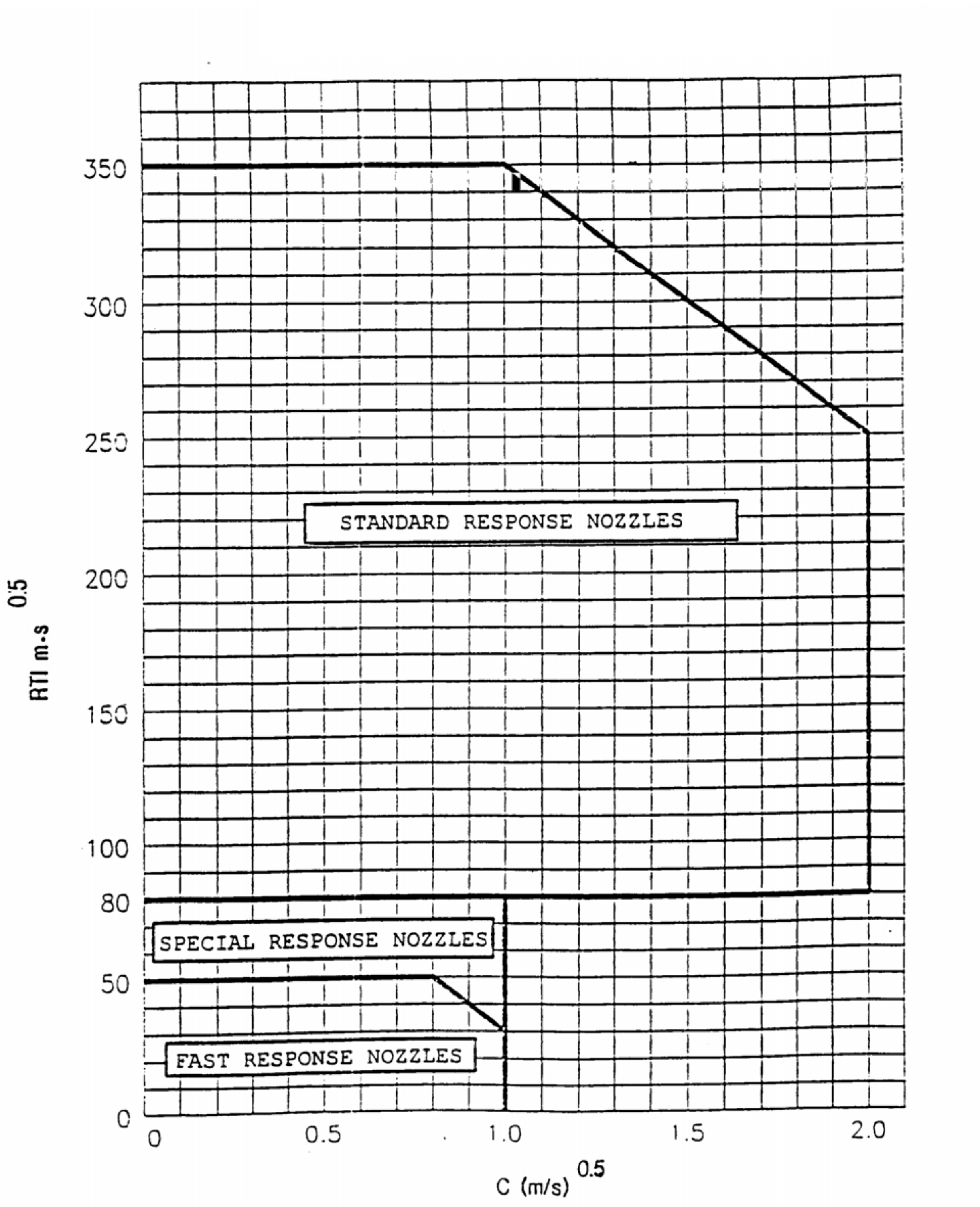


FIGURE 2

IMPACT TEST APPARATUS

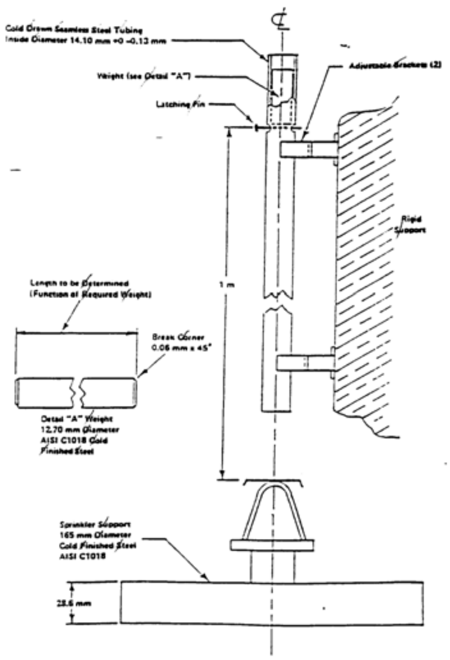
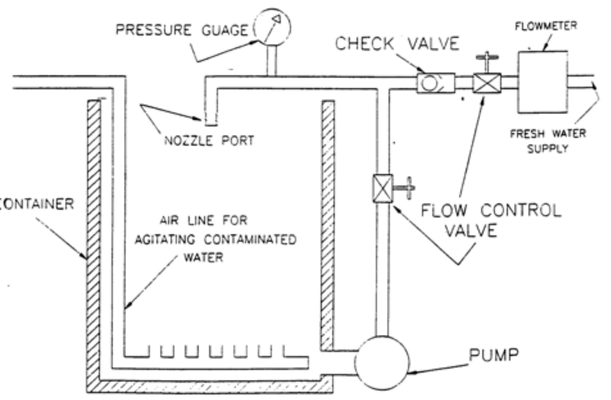


FIGURE 3

CLOGGING TEST APPARATUS



APPENDIX 2

FIRE TEST PROCEDURES FOR EQUIVALENT SPRINKLER SYSTEMS IN ACCOMMODATION, PUBLIC SPACE AND SERVICE AREAS ON PASSENGER SHIPS

1 SCOPE

1.1 These test procedures describe a fire test method for evaluating the effectiveness of sprinkler systems equivalent to systems covered by regulation II-2/12 of the SOLAS Convention [1*] in accommodation and service areas on board ships. It should be noted that the test method is limited to the systems' effectiveness against fire and is not intended for testing of the quality and design parameters of the individual components in the system.

1.2 In order to fulfil the requirements of 3.5 of the guidelines, the system must be capable of fire control or suppression in a wide variety of fire loading, fuel arrangement, room geometry and ventilation conditions.

1.3 Products employing materials or having forms of construction differing from the requirements contained herein may be examined and tested in accordance with the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with this document.

1.4 Products complying with the text of this document will not necessarily be judged to comply, if, when examined and tested, are found to have other features which impair the level of safety contemplated by this document.

2 HAZARD AND OCCUPANCY CLASSIFICATIONS

For the purposes of identifying the different fire risk classifications, table 1 is given, which correlates the fire tests with the classification of occupancy defined in SOLAS regulation II-2/26[1]:

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[*] Figures in square brackets in the text indicate the referenced publications listed later in this document.

Table 1

Correlation between fire tests with the classification of occupancy defined in SOLAS regulation II-2/26.2.2

	Corresponding fire test				
Occupancy classification	Section 5 cabin	Section 5 corridor	Section 6 luxury cabin	Section 7 public spaces	Section 8 shopping and storage
(1) Control stations				X	
(2) Stairways		X [1]			

(3) Corridors		X [1]			
(6) Accommodation spaces of minor fire risk	X [2]		X [3]	X [4]	
(7) Accommodation spaces of moderate fire risk	X [2]		X [3]	X [4]	
(8) Accommodation spaces of greater fire risk				X	
(9) Sanitary & similar spaces	X [2]		X [3]	X [4]	
(13) Store rooms, workshops, pantries, etc.					X
(14) Other spaces in which flammable liquids are stowed					X

Note: For examples of occupancies in each category, see SOLAS regulation II-2/26[1]

[1] For corridors and stairways wider than 1.5 m, use section 7 public space fire test instead of the corridor fire test

[2] For spaces up to 12 m^2

[3] For spaces from 12 m^2 up to 50 m^2

[4] For spaces over 50 m^2.

3 DEFINITIONS

3.1 **Fire suppression**: Sharply reducing the heat release rate of a fire and preventing its regrowth by means of a direct and sufficient application of water through the fire plume to the burning fuel surface [2].

3.2 **Fire control**: Limiting the size of a fire by distribution of water so as to decrease the heat release rate and pre-wet adjacent combustibles, while controlling ceiling gas temperatures to avoid structural damage [2].

3.3 **Fire source**: Fire source is defined as the combustible material in which the fire is set and the combustible material covering walls and ceiling.

3.4 **Igniter**: The device used to ignite the fire source.

4 GENERAL REQUIREMENTS

4.1 Nozzle positioning

The testing organization should be responsible for assuring that the nozzles for each fire test are installed in accordance with the manufacturer's design and installation instructions. The tests should be performed at the maximum specified spacings, installation height and distances below the ceiling. In addition, if the testing organization finds it necessary, selected fire tests should also be conducted at minimum specified spacings, installation height and distances below the ceiling.

4.2 Water pressure and flow rates

The testing organization should be responsible for assuring that all fire tests are conducted at the operating pressure and flow rates specified by the manufacturer.

4.3 Temperature measurements

Temperatures should be measured as described in detail under each chapter. Chromelalumel not exceeding 0.5 mm diameter welded together and chromelalumel 0.8 mm should be used. The 0.8 mm thermocouple wires should be twisted three times, have the end remaining wire cut off and be heated with an oxyacetylene torch to melt and form a small ball. The temperatures should be measured continuously, at least once every two seconds, throughout the tests.

4.4 Environmental conditions

The test hall should have an ambient temperature of between 10ºC to 30ºC at the start of each test.

4.5 Tolerances

Unless otherwise stated, the following tolerances should apply:

.1 Length ±2% of value

.2 Volume ±5% of value

.3 Pressure ±3% of value

.4 Temperature ±5% of value

These tolerances are in accordance with ISO standard 6182-1, February 1994 edition [4].

4.6 Observations

The following observations should be made during and after each test:

.1 Time of ignition.

.2 Activation time of each nozzle.

.3 Time when water flow is shut off.

.4 Damage to the fire source.

.5 Temperature recordings.

.6 System flow rate and pressure.

.7 Total number of operating nozzles.

4.7 Fire sources

If the requirements for fire sources specified in the following sections of this test method cannot be fulfilled, it is the responsibility of the test laboratory to show that alternative materials used have burning characteristics similar to those of specified materials.

4.8 Produce and documentation requirements

A draft copy of the design, installation and operating instruction manual should be furnished for use as a guide in the testing of the fire protection system devices.

The instructions should reference the limitations of each device and should include at least the following items:

.1 Description and operating details of each device and all accessory equipment, including identification of extinguishing system components or accessory equipment by part or model number.

.2 Nozzle design recommendation and limitations for each fire type.

.3 Type and pressure rating of pipe, tubing and fittings to be used.

.4 Equivalent length values of all fittings and all system components through which water flows.

.5 Discharge nozzle limitations, including maximum dimensional and area coverage, minimum and maximum installation height limitations, and nozzle permitted location in the protected volume.

.6 Range of filling capacities for each size storage container.

.7 Details for the proper installation of each device, including all component equipment.

.8 Reference to the specific types of detection and control panels (if applicable) to be connected to the equipment.

.9 Operating pressure ranges of the system.

.10 Method of sizing pipe or tubing.

.11 Recommended orientation of tee fittings and the splitting of flows through tees.

.12 Maximum difference in operating (flowing) pressure between the hydraulically closest and most remote nozzle.

5 Cabin and corridor fire tests

5.1 Test arrangement

5.1.1 The fire tests should be conducted in a 3 m by 4 m, 2.4 m high cabin connected to the centre of a 1.5 m by 12 m long corridor, 2.4 m high with both ends open.

5.1.2 The cabin should be fitted with one doorway opening, 0.8 m wide and 2.2 m high, which provides for a 0.2 m lintel above the opening.

5.1.3 The walls of the cabin should be constructed from an inner layer of nominally 12 mm thick non-combustible wall board with a nominally 45 mm thick mineral wool liner. The walls and ceiling of the corridor and ceiling of the cabin should be constructed of nominally 12 mm thick non-combustible wall boards. The cabin should be provided with a window in the wall opposite the corridor for observation purposes during the fire tests.

5.1.4 The cabin and corridor ceiling should be covered with cellulosic acoustical panels. The acoustical panels should be nominally 12 mm to 15 mm thick and should not ignite when tested in accordance with IMO resolution A.653(16).

5.1.5 Plywood panels should be placed on the cabin and corridor walls. The panels should be approximately 3 mm thick. The ignition time of the panel should not be more than 35 s and the flame spread time at 350 mm position should not be more than 100 s as measured in accordance with IMO resolution A.653(16).

5.2 Instrumentation

During each fire test, the following temperatures should be measured using thermocouples of diameter not exceeding 0.5 mm:

.1 The ceiling surface temperature above the ignition source in the cabin should be measured with a thermocouple embedded in the ceiling material from above such that the thermocouple bead is flush with the ceiling surface.

.2 The ceiling gas temperature should be measured with a thermocouple 75 ± 1 mm below the ceiling in the centre of the cabin.

.3 The ceiling surface temperature in the centre of the corridor, directly opposite the cabin doorway, should be measured with a thermocouple embedded in the ceiling material such that the thermocouple bead is flush with the ceiling (see figure 1).

5.3 Nozzle positioning

The nozzles should be installed to protect the cabin and corridor in accordance with the manufacturer's design and installation instructions subject to the following:

.1 if only one nozzle is installed in the cabin, it may not be placed in the shaded areas in figure 2; and

.2 corridor nozzles should not be placed closer to the centreline of the cabin doorway than one half the maximum spacing recommended by the manufacturer. An exception is systems where nozzles are required to be placed outside each doorway.

5.4 Fire sources

5.4.1 Cabin test fire source

Two pullman type bunk beds having an upper and lower berth should be installed along the opposite side walls of the cabin (see figure 1). Each bunk bed should be fitted with 2.0 m by 0.8 m by 0.1 m polyether mattresses having a cotton fabric cover. Pillows measuring 0.5 m by 0.8 m by 0.1 m should be cut from the mattresses. The cut edge should be positioned towards the doorway. A third mattress should form a backrest for the lower bunk bed. The backrest should be attached in upright position in a way that prevents it from falling over (see figure 3).

The mattresses should be made of non-fire retardant polyether and they should have a density of approximately 33 kg/m^3. The cotton fabric should not be fire retardant treated and it should have an area weight of 140 g/m^2 to 180 g/m^2. When tested according to ISO 5660-1 (ASTM E-1354), the polyether foam should give results as given in the table below. The frame of the bunk beds should be of steel nominally 2 mm thick.

ISO 5660, Cone calorimeter test	
Test conditions	Irradiance 35 kW/m^2. Horizontal position. Sample thickness 50 mm. No frame retainer should be used.
Test results	**Foam**
Time to ignition(s)	2-6
3 minute average HRR, q_{180}(kW/m^2)	270 ± 50
Effective heat of combustion (MJ/kg)	28 ± 3
Total heat release (MJ/m^2)	50 ± 12

5.4.2 Corridor test fire source

The corridor fire tests should be conducted using eight piled polyether mattress pieces measuring 0.4 m by 0.4 m by 0.1 m, as specified in 5.4.1, without fabric covers. The pile should be placed on a stand, 0.25 m high, and in a steel test basket to prevent the pile from falling over (see figure 4).

5.5 Test method

The following series of fire tests should be performed with automatic activation of the nozzle(s) installed in the cabin and/or corridor as indicated. Each fire should be ignited with a lighted match using an igniter made of some porous material, e.g. pieces of insulating fibreboard. The igniter may be either square or cylindrical shaped, 60 mm in square or 75 mm in diameter. The length should be 75 mm. Prior to the test the igniter should be soaked in 120 ml of heptane and wrapped in a plastic bag and positioned as indicated for each cabin fire test. For the corridor fire tests, the igniter should be located in the centre at the base of the pile of the mattress pieces, and on one side of the test stand at the base of the pile of the mattress pieces.

.1 Lower bunk bed test. Fire arranged in one lower bunk bed and ignited with the igniter located at the front (towards door) centreline of the pillow.

.2 Upper bunk bed test. Fire arranged in one upper bunk bed with the igniter located at the front (towards door) centreline of the pillow.

.3 Arsonist test. Fire arranged by spreading 1 l of white spirits evenly over one lower bunk bed and backrest 30 s prior to ignition. The igniter should be located in the lower bunk bed at the front (towards door) centreline of the pillow.

.4 Disabled nozzle test. The nozzle(s) in the cabin should be disabled. Fire arranged in one lower bunk bed and ignited with the igniter located at the front (towards door) centreline of the pillow.

If nozzle(s) in the cabin are linked with nozzle(s) in the corridor such that a malfunction would affect them all, all cabin and corridor nozzles linked should be disabled.

.5 Corridor test. Fire source located against the wall of the corridor under one nozzle.

.6 Corridor test. Fire source located against the wall of the corridor between two nozzles.

The fire tests should be conducted for 10 min after the activation of the first nozzle, and any remaining fire should be extinguished manually.

5.6 Acceptance criteria

Based on the measurements, a maximum 30 s average value should be calculated for each measuring point which forms the temperature acceptance criteria.

Acceptance criteria for the cabin and corridor tests

		Maximum 30 s. average ceiling surface temperature in the cabin (ºC)	Maximum 30 s. average ceiling gas temperature in the cabin (ºC)	Maximum 30 s. average ceiling surface temperature in the corridor (ºC)	Maximum acceptable damage on mattresses (%)		Other criteria
					Lower bunk	Upper bunk	
Cabin tests	lower bunk bed	360	320	120	40	10	No nozzles in corridor allowed to operate[3]
	upper bunk bed				N.A.	40	
	arsonist	N.A.	N.A.	120	N.A.	N.A.	N.A.
Corridor		N.A.	N.A.	120 [1]	N.A.		Only two independent nozzles in corridor allowed to operate[4]
Disabled nozzle		N.A.	N.A.	400 [2]	N.A.		N.A.

1 In each test, the temperature should be measured above the fire source.
2 The fire is not allowed to propagate along the corridor beyond the nozzles closest to the door opening
3 Not applicable, if cabin nozzle(s) are linked to corridor nozzle(s)
4 Not applicable, if corridor nozzle(s) are linked together.
N.A. Not applicable.

Note: After the test, the fire sources should be examined visually to determine compliance with the required maximum damage. The damages should be estimated using the following formula:

Damage to lower bunk bed = (damage to horizontal mattress (%) + 0.25 x damage to pillow (%) + damage to backrest (%))/2.25

Damage to upper bunk bed = (damage to horizontal mattress (%) + 0.25 x damage to pillow (%))/1.25

If it is not clearly obvious by visual examination whether the criteria are fulfilled or not, the test should be repeated.

6 LUXURY CABIN FIRE TESTS

6.1 Test arrangement

These fire tests should be conducted in a 2.4 m high room having equal sides and a floor area of at least 25 m^2, but not exceeding 80 m^2. The room should be fitted with two doorway openings, in cross corners opposite the fire source. Each opening should be 0.8 m wide and 2.2 m high, which provides for a 0.2 m lintel above the openings. Walls and ceilings should be made of non-combustible, nominally 12 mm thick, wall boards.

The test room ceiling should be covered 2.4 m out from the corner with cellulosic acoustical panels. The acoustical panels should be nominally 12 mm to15 mm thick, and should not ignite when tested in accordance with IMO resolution A.653(16).

Plywood panels should be placed on two of the test room walls and extending 2.4 m out from the corner with the fire source. The panels should be approximately 3 mm thick. The ignition time of the panel should not be more than 35 s and the flame spread time at 350 mm position should not be more than 100 s as measured in accordance with IMO resolution A.653(16) (see figure 5).

6.2 Instrumentation

During the fire tests the following temperatures should be measured. Note that the instrumentation may be different, dependent on which of two types of fire sources are used.

.1 The ceiling material temperature above the ignition source should be measured using a 0.8 mm thermocouple embedded in the ceiling, 6.5 ± 0.5 mm from the surface.

.2 The ceiling gas temperature should be measured using a 0.8 mm thermocouple located 75 ± 1 mm below the ceiling within 0.2 m horizontally from the closest nozzle to the corner.

.3 The ceiling surface temperature above the ignition source should be measured using a thermocouple with diameter not exceeding 0.5 mm embedded in the ceiling material such that the thermocouple bead is flush with the ceiling surface.

.4 The ceiling gas temperature should be measured using a 0.5 mm thermocouple located 75 ± 1 mm below the ceiling within 0.2 m horizontally from the closest nozzle to the corner.

Measurements in accordance with .1 and .2 should apply when a fire source in accordance with 6.4.1 is used and .3 and .4 when a fire source in accordance with 6.4.2 is used (see figure 5).

6.3 Nozzle positioning

The distance between the outer nozzle and the walls should be one half the maximum nozzle spacing specified by the manufacturer. The distance between nozzles should be equal to the maximum spacing specified by the manufacturer.

Nozzles should be positioned with their frame arms parallel and perpendicular with the walls of the cabin, or for nozzles without frame arms, so that the lightest discharge density will be directed towards the fire area.

If non-uniform installation is selected by the manufacturer, the maximum spacing is established in the open public space scenario.

6.4 Fire source

The fire source should consist of a wood crib and a simulated furniture (i.e. UL 1626 Residential Sprinkler fuel package [7]) or, alternatively, an upholstered chair (i.e. FM 2030 Residential fuel package [8]).

6.4.1 Wood crib/simulated furniture description

The wood crib should weigh approximately 6 kg and should be dimensioned 0.3 m by 0.3 m by 0.3 m. The crib should consist of eight alternate layers of four trade size nominal 38 mm by 38 mm kiln-dried spruce or fir lumber 0.3 m long. The alternate layers of the lumber should be placed at right angles to the adjacent layers. The individual wood members in each layer should be evenly spaced along the length of the previous layer of wood members and stapled together.

After the wood crib is assembled, it should be conditioned at a temperature of 50 ± 3ºC for not less than 16 h. Following the conditioning, the moisture content of the crib should be measured at various locations with a probe type moisture meter. The moisture content of the crib should not exceed 5% prior to the fire test. The crib should be placed on top of a 0.3 m by 0.3 m, 0.1 m high steel test tray and positioned 25 mm from each wall.

The simulated furniture should consist of two 76 mm thick uncovered polyether foam cushions having a density of 16 kg/m^3 to 20 kg/m^3, a compressive strength of 147 N to 160 N, measuring 0.9 m by 1.0 m, each attached to a wood support frame. The wood support frame should have a rectangular plywood face measuring approximately 810 mm by 760 mm on to which the foam cushions are applied. The cushions should be stretched and stapled on to plywood panels which extend perpendicular to the face towards the opposite end of the frame by approximately 180 mm. Each cushion should overlap the top of the wood frame by approximately 150 mm and the sides of the wood frame by approximately 180 mm.

This fuel package has an ultra-fast t^2 fire growth, a maximum heat release in excess of 2.5 MW and a growth time (time to reach 1 MW) of 80 ± 10 s (see figure 5).

6.4.2 Upholstered chair description

The fuel package consists of the following items (see figure 6):

Item	Code	No. of units	Dimensions and description
Simulated sofa end	S	1	19 mm plywood structure, open top and bottom, 610 mm by 914 mm, 610 mm high
Chair (recliner)[1]	C	1	Custom-made reclining chair approximately 760 mm by 914 mm, 990 mm high. All new materials consisting of vinyl covering with cotton backing (4.54 kg); polyurethane foam (seat 2.27 kg, 127 mm thick); polyurethane (arms, 1.36 kg, 25 mm thick); pine structure; total weight 23.8 kg, built by Old Brussels of Sturbridge, Massachussetts
End table	E	1	Table top; 19 mm particle board, 660 mm by 495 mm; table legs are softwood, i.e. pine, fir, etc; 38 mm by 38 mm, 514 mm high
Curtains	CW	4	2 panels, rod pocket panels (1,016 mm by 1,829 mm), fabric blend: 50% polyester, 50% cotton
			2 panels sheer rod pocket panels (1,016 mm by 1,829 mm), (100% polyester batiste)

[1]An equivalent chair may be specified as a fire source with maximum heat release rate of 1.5 MW, a Required Delivered Density of 5 mm/min, and a growth time of (time to reach 1 MW assuming second power growth in time) of 75s -125 s.

6.5 Test method

The fire tests should be conducted for 10 min after the activation of the first nozzle, and any remaining fire should be extinguished manually.

6.5.1 Wood crib/simulated furniture

0.2 l of heptane should be placed on a 5 mm water base in the test tray positioned directly below the wood crib. Approximately 120 g total of excelsior (wood wool) should be pulled apart and loosely positioned on the floor with approximately 60 g adjacent to each section of the simulated furniture.

The heptane should be ignited and 40 s later the excelsior should also be ignited.

6.5.2 Upholstered chair

Ignition should take place using a lighted match at the centre of two horizontal axially parallel and adjacent 0.3 m long cotton wicks, each 9.3 mm in diameter, saturated with 25 cl of ethyl alcohol. The wick should be positioned at the base of the chair as described in figure 6, within 2 min prior to ignition.

6.6 Acceptance criteria

Based on the measurements, a maximum of 30 s average value should be calculated for each measuring point which forms the temperature acceptance criteria.

	Max. 30 s average ceiling material/surface temperature (^oC)	Max. 30 s average ceiling gas temperature (^oC)
Fire source		
As per 6.4.1	260	320
As per 6.4.2	260	320

7 PUBLIC SPACE FIRE TESTS

7.1 Test arrangements

The fire tests should be conducted in a well-vented building under a ceiling of at least 80 m^2 in area with no dimension less than 8 m. There should be at least a 1 m space between the perimeters of the ceiling and any wall of the test building. The ceiling height should be set at 2.5 m and 5.0 m respectively.

Two different tests should be conducted as per 7.1.1 and 7.1.2.

7.1.1 Open public space test

The fire source should be positioned under the centre of the open ceiling so that there is an unobstructed flow of gases across the ceiling. The ceiling should be constructed from a non-combustible material.

7.1.2 Corner public space test

The test should be conducted in a corner constructed by two at least 3.6 m wide, nominally 12 mm thick, non-combustible wall boards.

Plywood panels should be placed on the walls. The panels should be approximately 3 mm thick. The ignition time of the panel should not be more than 35 s and the flame spread time at 350 mm position should not be more than 100 s measured in accordance with IMO resolution A.653(16).

The ceiling should be covered, 3.6 m out from the corner, with cellulosic acoustical panels. The acoustical panels should be nominally 12-15 mm thick, and should not ignite when tested in accordance with IMO resolution A.653(16).

7.2 Instrumentation

During each fire test, the following temperatures should be measured using thermocouples with diameter not exceeding 0.5 mm.

7.2.1 Open public space test

.1 The ceiling surface temperature above the ignition source should be measured using a thermocouple embedded in the ceiling material such that the thermocouple bead is flush with the ceiling surface.

.2 The ceiling gas temperature should be measured using a thermocouple located 75 ± 1 mm below the ceiling 1.8 m from ignition.

7.2.2 Corner public space test

.1 The ceiling surface temperature above the ignition source should be measured using a thermocouple embedded in the ceiling material such that the thermocouple bead is flush with the ceiling surface.

.2 The ceiling gas temperature should be measured using a thermocouple located 75 ± 1 mm below the ceiling within 0.2 m horizontally from the closest nozzle to the corner.

7.3 Nozzle positioning

For nozzles with frame arms, tests should be conducted with the frame arms positioned both perpendicular and parallel with the edges of the ceiling or corner walls. For nozzles without framed arms, the nozzles should be orientated so that the lightest discharge density will be directed towards the fire area.

7.4 Fire sources

7.4.1 Open public space

The fire source should consist of four sofas made of mattresses as specified in 5.4.1 installed in steel frame sofas. The sofas should be positioned as shown in figure 7 spaced 25 mm apart.

One of the middle sofas should be ignited, centric and at the bottom of the backrest, with an igniter as described in 5.5.

7.4.2 Corner public space test

The fire source should consist of a sofa, as specified in 7.4.1, placed with the backrest 25 mm from the right hand wall and close up to the left hand wall. A target sofa should be placed along the right hand wall with the seat cushion 0.1 m from the first sofa and another target sofa should be placed 0.5 m from it on the left hand side. The sofa should be ignited using an igniter, as described in 5.5, that should be placed at the far left of the corner sofa, at the base of the backrest, near the left hand wall (see figure 8).

7.5 Test method

The fire tests should be conducted for 10 min after the activation of the first nozzle, and any remaining fire should be extinguished manually.

7.5.1 Open public space tests

Fire tests should be conducted with the ignition centred under one, between two and below four nozzles.

7.5.2 Corner public space test

Two fire tests should be conducted with at least four nozzles arranged in a 2 x 2 matrix. For the second fire test, the nozzle closest to the corner should be disabled.

7.6 Acceptance criteria

Based on the measurements, a maximum 30 s average value should be calculated for each measuring point which forms the temperature acceptance criteria.

7.6.1 Acceptance criteria for the public space tests

		Maximum 30 s. average ceiling surface temperature (ºC)	Maximum 30 s. average ceiling gas temperature (ºC)	Maximum acceptable damage on mattresses (%)
Open space		360	220 [2]	50/35[1]
Corner	normal	360	220	50/35[1] (ignition sofa) No charring of target sofas
	disabled nozzle	N.A.	N.A.	50 (target sofas)

[1] 50% is the upper limit for any single test. 35% is the upper limit for the average of the public space tests required in 7 and 9 at each ceiling height (excluding the disabled sprinkler test).

[2] The gas temperature should be measured at four different positions and the evaluation of the results is based on the highest reading.

N.A. Not applicable.

8 SHOPPING AND STORAGE AREA FIRE TESTS

8.1 Test arrangements

As per 7.1 but with 2.5 m ceiling height only.

8.2 Instrumentation

No temperature measurements are required.

8.3 Nozzle positioning

As per 7.3.

8.4 Fire source

The fire source should consist of two central, 1.5 m high, solid piled stacks of cardboard boxes packed with polystyrene unexpanded plastic cups with a 0.3 m flue space. Each stack should be approximately 1.6 m long and 1.1 m to 1.2 m wide.

A suitable plastic commodity is the FMRC standard plastic commodity [9]. Similar commodities might be used if they are designed in a similar way and are proven to have the same burning characteristics and suppressability.

The fire source should be surrounded by six 1.5 m high solid piled stacks of empty cardboard boxes forming a target array to determine if the fire will jump the aisle. The boxes should be attached to each other, for example by staples, to prevent them from falling over (see figure 9).

8.5 Test method

Fire tests should be conducted with the ignition centred under one, between two and below four nozzles.

Each fire should be ignited with a lighted match using two igniters as described in 5.5. The igniters should be located placed on the floor, each against the base of one of the two central stacks and ignited simultaneously.

The fire tests should be conducted for 10 min after the activation of the first nozzle, and any remaining fire should be extinguished manually.

8.6 Acceptance criteria

.1 No ignition or charring of the target cartons is allowed.

.2 No more than 50% of the cartons filled with plastic cups should be consumed.

9 VENTILATION TEST

One corner public space test of 7 and the corridor space test which has given the worst result among those in 5.4.2 should be repeated with the ambient air having a minimum velocity of 0.3 m/s.

The ambient air velocity in the public space tests should be measured 1 m above the floor and 1 m below the ceiling at a location 5 m out from the corner, midway between the enclosure walls. Air velocity in the corridor should be measured at the mid-height.

9.1 Acceptance criteria

The fire should not progress to the edge of the combustible wall or ceiling.

10 REFERENCED PUBLICATIONS

[1] *SOLAS, The International Convention for Safety of Life at Sea*, International Maritime Organization

[2] Solomon, Robert E., *Automatic Sprinkler Systems Handbook*, National Fire Protection Association, Batterymarch Park, Quincy, MA, USA, 5th edition, 1991

[3] ANSI/UL 723, *Surface Burning Characteristics of Building Materials*

[4] ISO 6182/1 February 1994 edition

[5] ISO 5660-1, *Fire Tests - Reaction to fire - Rate of heat release from building products (Cone calorimeter method)*, 1st edition, 1993

[6] Babrauskas, V. and Wetterlund, I., *Instructions for Cone calorimeter testing of furniture samples*, CBUF Consortium, SP-AR 1993:65, Borås, Sweden, 1993

[7] *Standard for Residential Sprinklers for Fire-Protection Service*, UL 1626, Underwriters Laboratories Inc., Northbrook, IL, USA, December 28, 1990 revision

[8] *Approval Standard for Residential and Limited Water Supply Automatic Sprinklers,* Class 2030, Factory Mutual Research Corporation, Norwood, MA, USA, January 27, 1993

[9] Chicarello, Peter, J., Troup, Joan, M.A., *Fire Products Collector Test Procedure for Determining the Commodity Classification of Ordinary Combustible Products*, Factory Mutual Research Corporation, Norwood, MA, USA, August, 1990

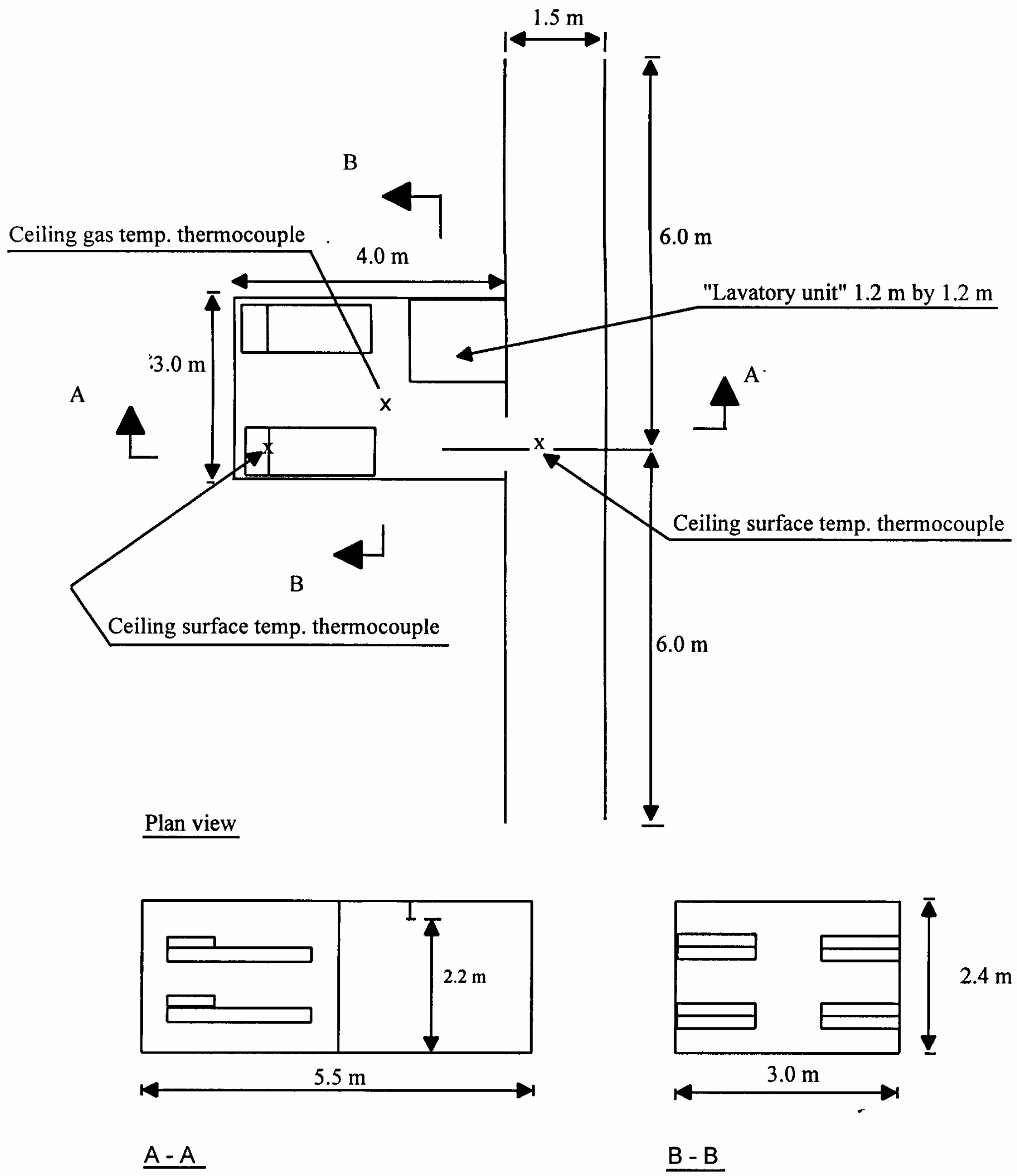

1.5 m
B
Ceiling gas temp. thermocouple
4.0 m
6.0 m
"Lavatory unit" 1.2 m by 1.2 m
3.0 m
A
A
x
x
x
Ceiling surface temp. thermocouple
B
Ceiling surface temp. thermocouple
6.0 m
Plan view
2.2 m
2.4 m
5.5 m
3.0 m
A - A
B - B

Figure 1

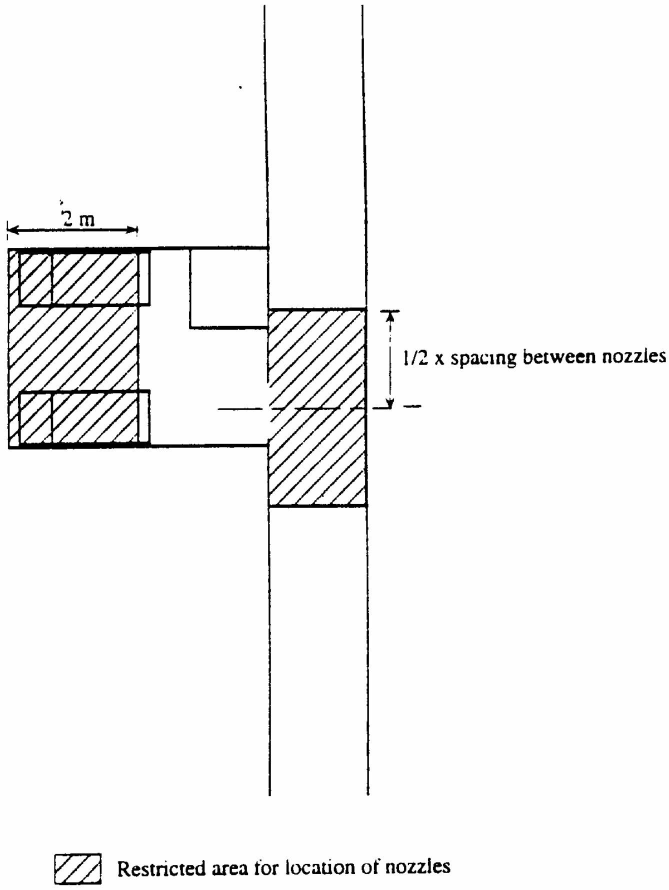

2 m
1/2 x spacing between nozzles
Restricted area for location of nozzles

Figure 2

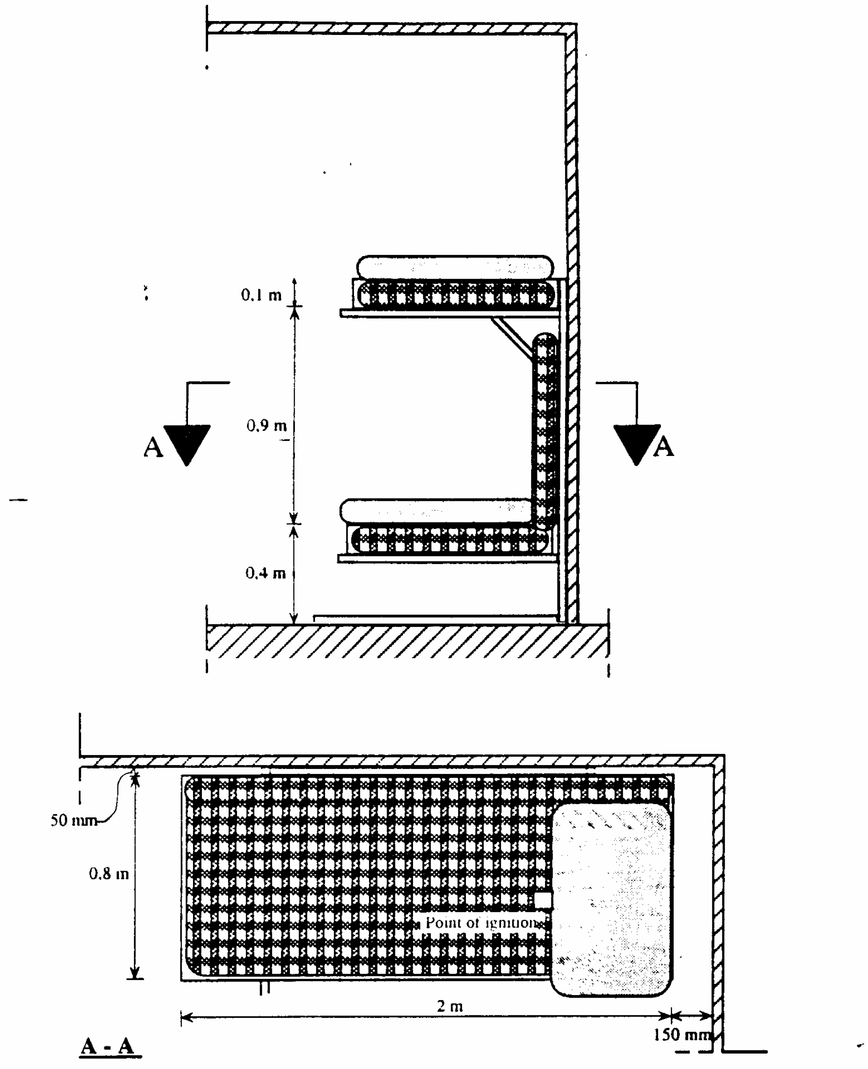


Figure 3

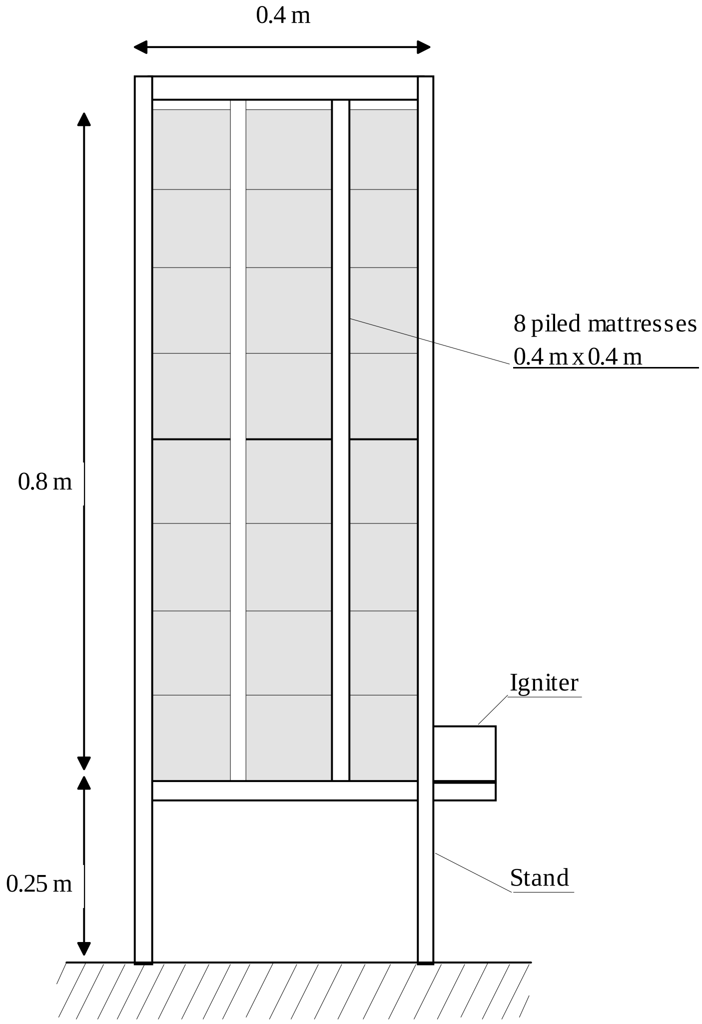


Figure 4

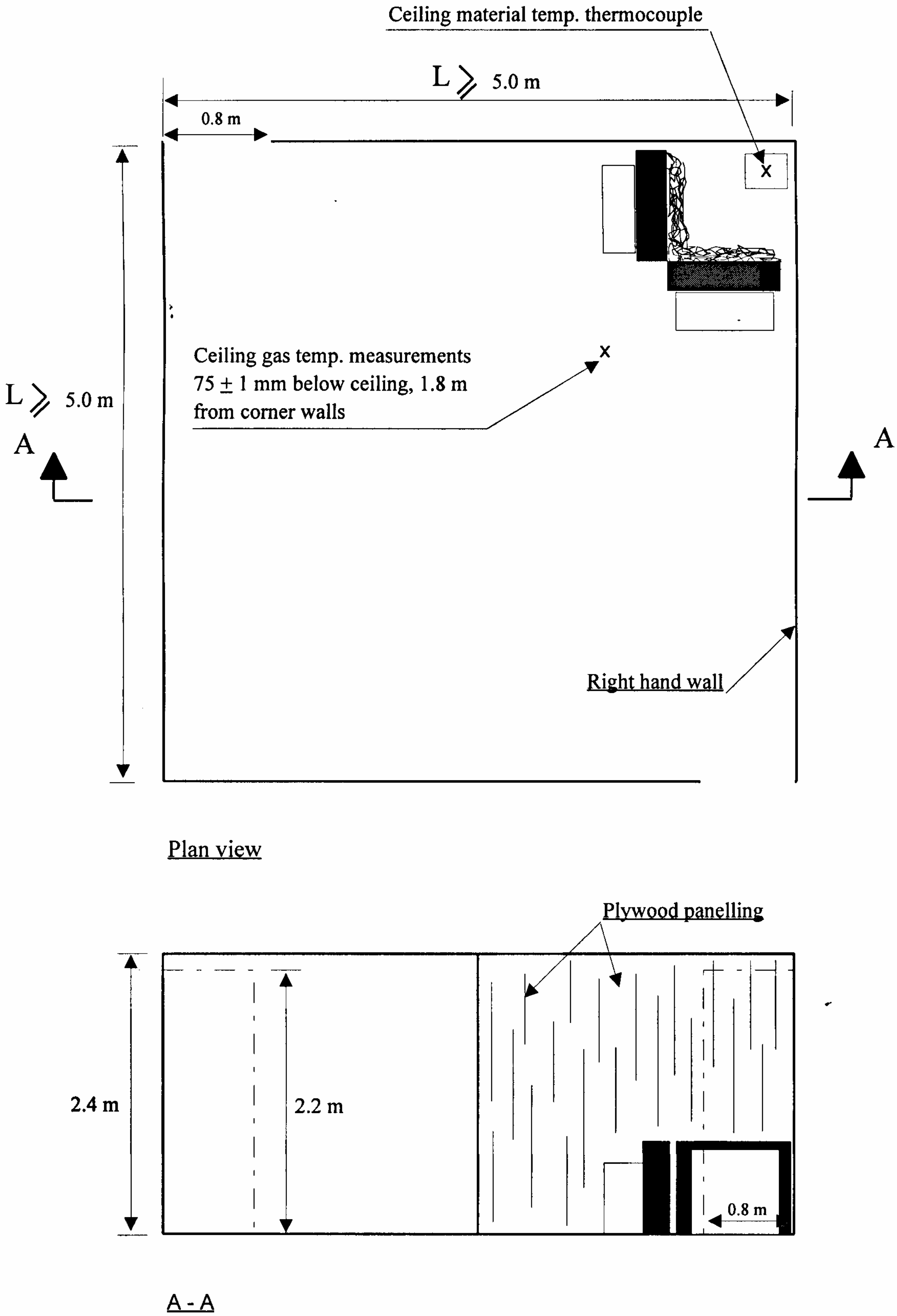


Figure 5
(shown with wood crib/simulated furniture)

Upholstered chair fuel package
(dimensions in metres)

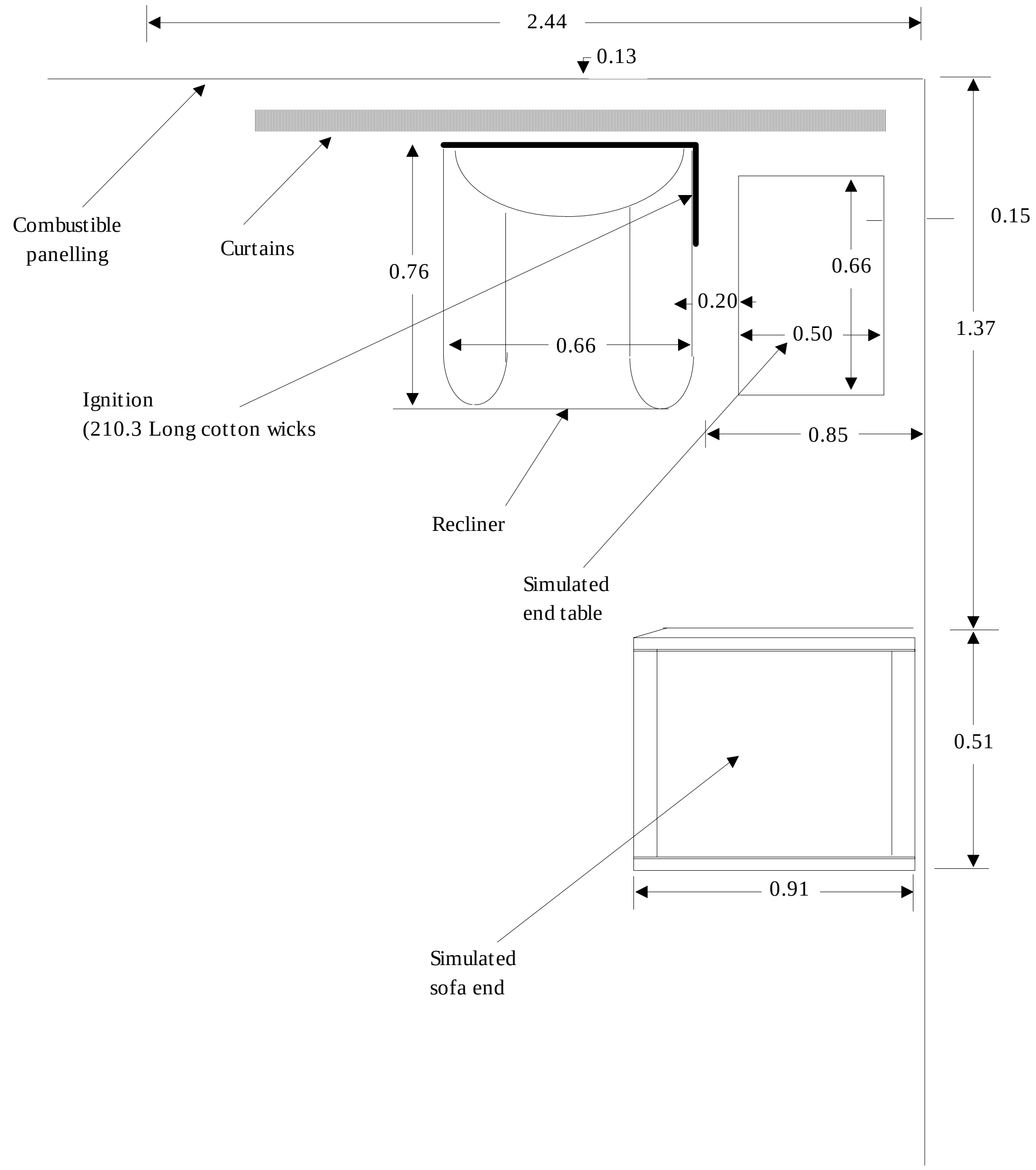


Figure 6

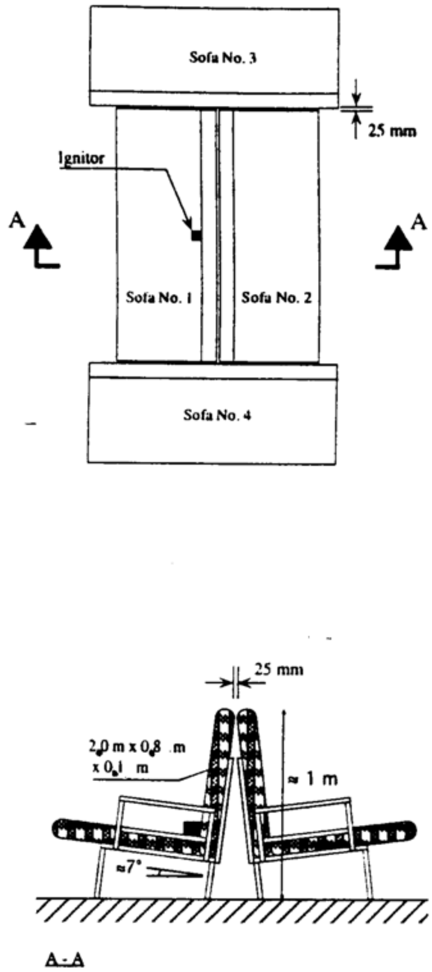
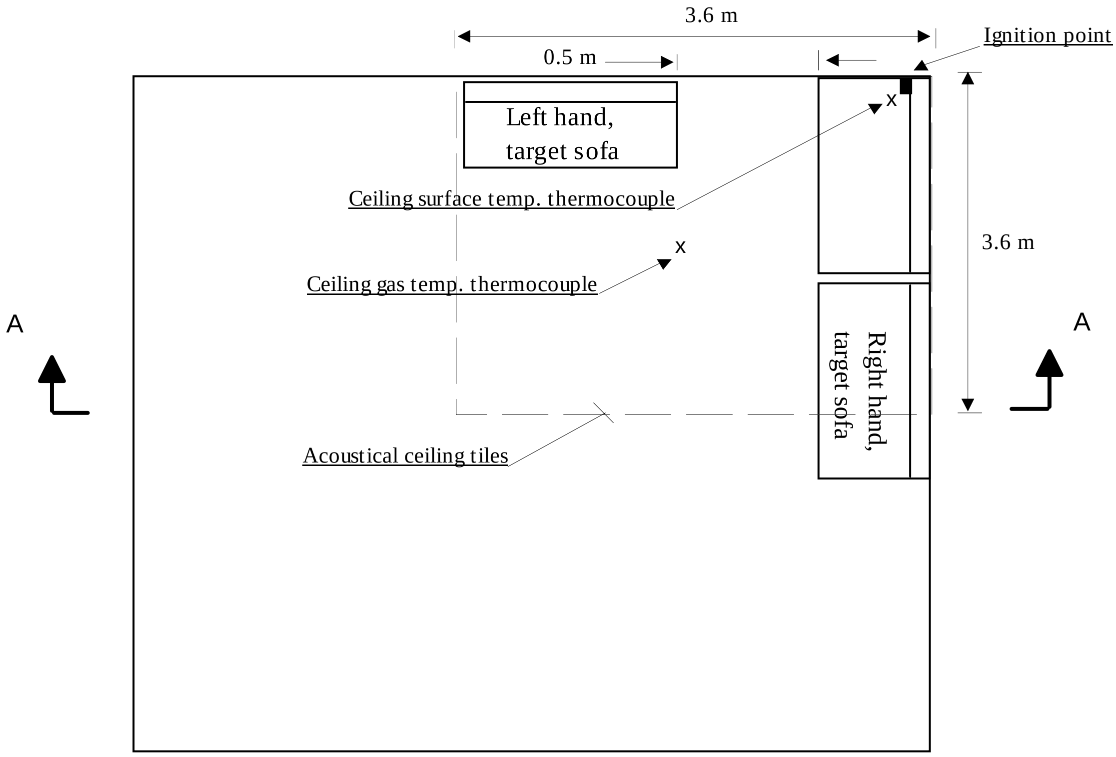
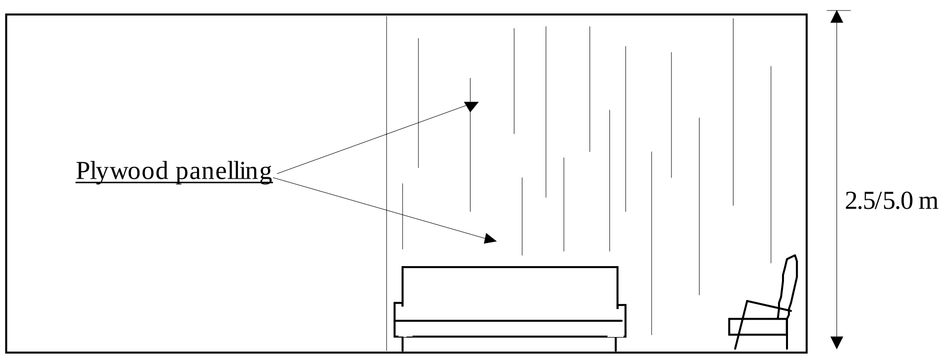

Sofa No. 3
25 mm
Ignitor
A
A
Sofa No. 1
Sofa No. 2
Sofa No. 4
25 mm
2,0 m x 0,8 m
x 0,1 m
≈ 1 m
≈7°
A-A

Figure 7

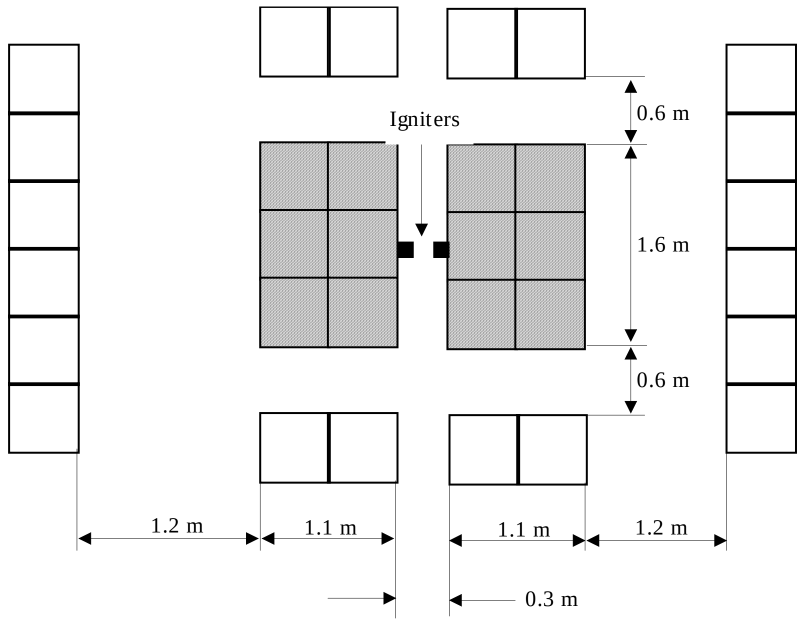


Plan view

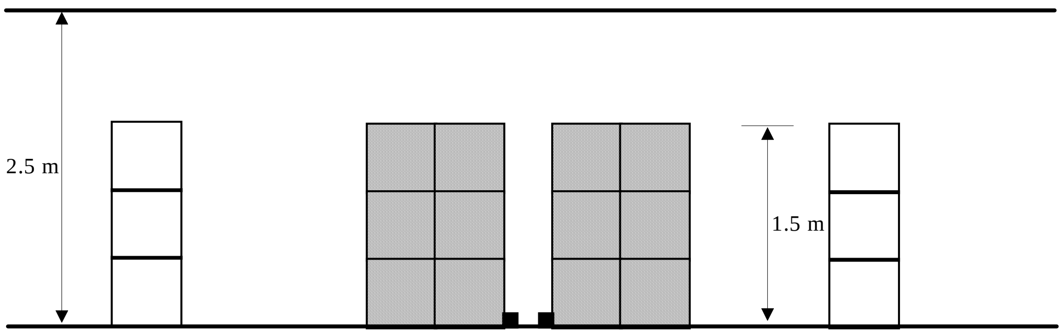


A - A

Figure 8



Plan view



Front view

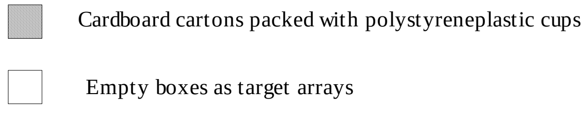


Figure 9